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INTRODUCTION

Objective and Scope of Investigation

The specific purpose of this study is to determine the character, thickness, and chronological sequence of all outcropping sedimentary rocks in Riley County. An effort will be made to summarize the lithologic and paleontologic data for each stratigraphic unit, formulate certain conclusions, and state some of the problems for further more intensive studies of the stratigraphy of the county.

This investigation covers only the rocks that crop out in Riley County, Kansas. The stratigraphic units involved are those of the Pennsylvanian and Permian systems of late Paleozoic age and a few feet of the Dakota sandstone of the Cretaceous system, of Mesozoic age. Three igneous intrusions crop out in this county, and the age of these plugs is believed to be late Cretaceous. Good sections of the formations in the upper Pennsylvanian and lower Permian systems are available for study (Table I).

The presentation of data is based on the chronologic sequence in which the formations of the several systems was deposited. The one who named each stratigraphic unit and designated its type locality will be given. This will be followed by a historical review of the more important earlier descriptions.

The areal distribution of each unit will be stated, and the unit will be described on the basis of its lithology and paleontology as observed in Riley County. Frequent reference will be

made to the measured sections appended to this report.

Location and Size of Area Investigated

Riley County, Kansas, has an area of approximately 560 square miles and is composed of about 16 townships. It lies in the second tier of counties south of Nebraska, and is the fifth county west of the Kansas-Missouri boundary (Fig. I). Riley County is bordered on the north by Washington and Marshall Counties, on the west by Clay County, on the south by Geary County, and by Pottawatomie and Wabaunsee Counties on the east. Riley County is 36 miles long and is approximately 31 miles wide. The county is L-shaped, the base of the "L" being directed toward the east along the southern boundary. An area of about 50 square miles of Riley County was added to the Fort Riley Military Reservation during the past war. This area lies northwest from Ogden, Kansas.

The principal streams in Riley County are the Kansas and Blue Rivers. The Kansas River enters the county from the southwest, flows northeast to Manhattan, and then turns toward the east. The eastward-flowing part of the river forms the northern boundary of the southeastern extension of the county. The Blue River enters the county from the north and joins the Kansas River 1.5 miles east of Manhattan. The Blue River forms the eastern boundary of the county from the north county line to Manhattan. Other important streams in the county are Deep Creek, Wildcat Creek, Mill Creek, and Fancy Creek. Only Fancy Creek flows the full width of the county.

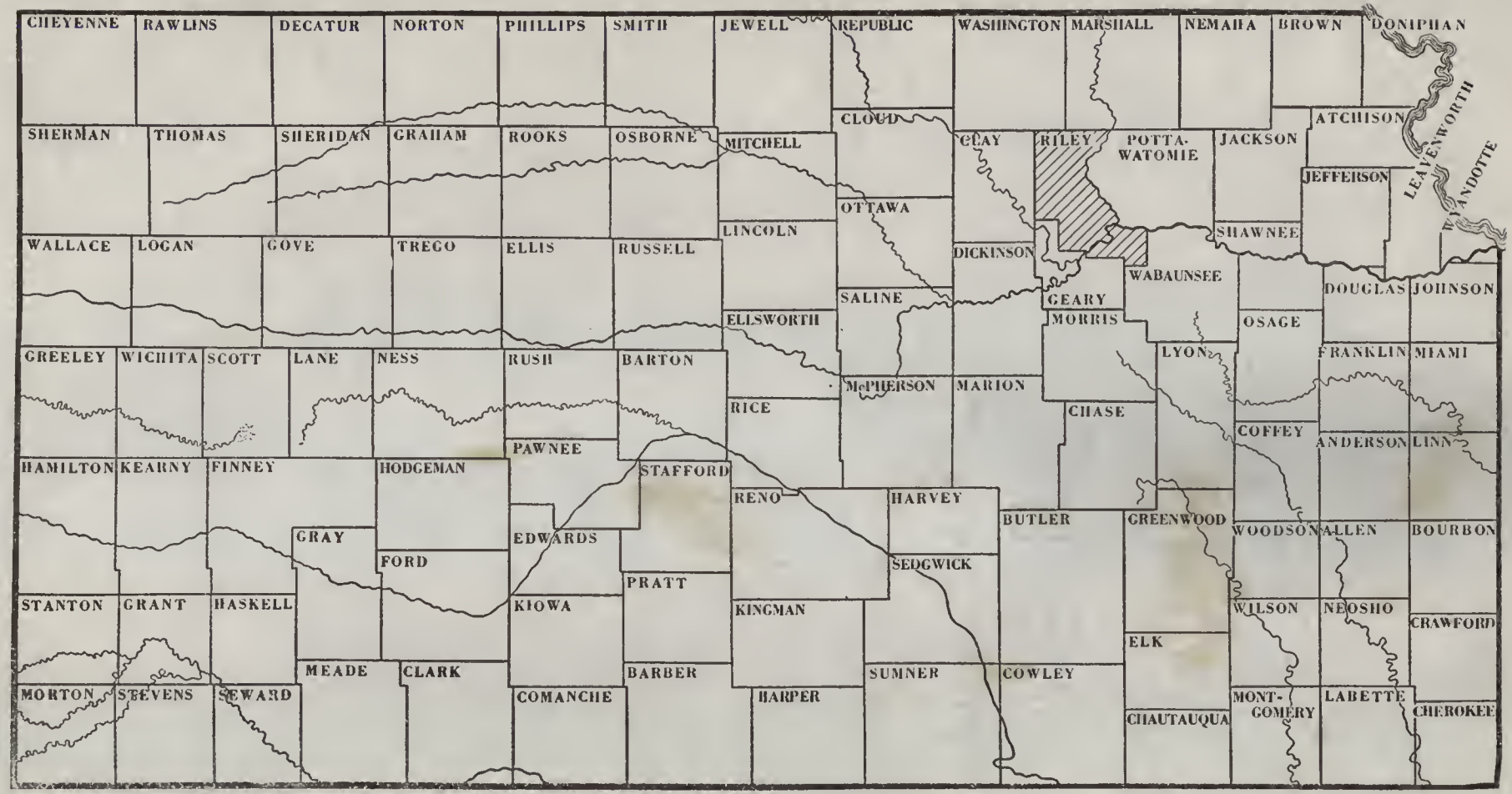

Fig. I. Area covered by this thesis.

Investigation Procedure

Preliminary investigations were begun in the fall of 1947 and continued through the spring of 1948. Field work was resumed in the fall of 1948 and completed in the spring of 1949.

A thorough reconnaissance was made of the entire county. Formations were identified and sections were measured. A grid was drawn, on acetate, to the scale of 3 inches equals 1 mile. The grid was based on the 1 inch equals 1 mile Highway Transportation Map provided by the State Highway Commission of Kansas as amended by aerial photographs. Drainage was applied to the base map from the aerial photographs through the use of a Sketchmaster. The base map was compiled in units of single townships for convenience in mapping.

The geologic formations, as identified in the field, were traced on the acetate base map from aerial photographs. Two successive formations, a limestone overlain by a shale, were consolidated as a map unit. Such consolidation was thought necessary because, on a map drawn to this scale, a single formation would occupy a band so narrow that its labeling and identification would be almost impossible. Much of the field mapping was done in collaboration with H. V. Peck of the Department of Geology, Kansas State College. Mr. Peck mapped the formations of post-Cretaceous age. The investigation was made possible by its acceptance as a project in the construction materials program of the United States Geological Survey and all data are the property of that organization.

Inasmuch as the geology of the area had been previously mapped by Jewett (1941, Plate I), much field time was saved by referring to this map. The map compiled as the basis of this report, Plate I, is much more detailed than that compiled by Jewett. The two maps differ, further, in that one compiled by Jewett is one of the areal-geology type whereas the map upon which this report is based is one of the surficial-geology type. An area-geologic map, for the most part, shows only the outcrop areas of consolidated rocks.

Following the delineation of outcrop bands in the field, their contacts were traced on linen. The 16 township maps were combined in this step to the three panels into which Plate I is divided. The geologic cartography is that of Mrs. R. M. Soelter and C. Powers, both of the United States Geological Survey. Each panel was then reduced photostatically to one-half its original scale and the symbols and color patterns were then added.

Previous Geologic Investigation in the Area

The earliest investigation in the rocks of this area was made by Meek and Hayden (1860). A short time later Swallow (1866) described some of the exposures of rocks in this region. Broadhead (1874, pp. 401-403) described some of the rock units in this area and especially the section displayed in K-Mill southeast of Manhattan. Hay (1896) worked the geology of the Fort Riley Military Reservation and vicinity and, during the same year, Adams (1896, pp. 124-126) published a geologic section from Manhattan to

Abilene. Tschernyschew (1902, pp. 302-303) studied a stratigraphic section extending from Manhattan to Fort Riley. The most extensive work in this area was accomplished by Jewett (1941) who mapped the area and described its geology. Three master theses were based on the structural geology of part of Riley County. These were submitted by McMillan (1947), Crombs (1947), and A. Neff (1949).

Other less significant investigations, too numerous to mention, contributed considerable information pertaining to the stratigraphy of this and adjacent areas.

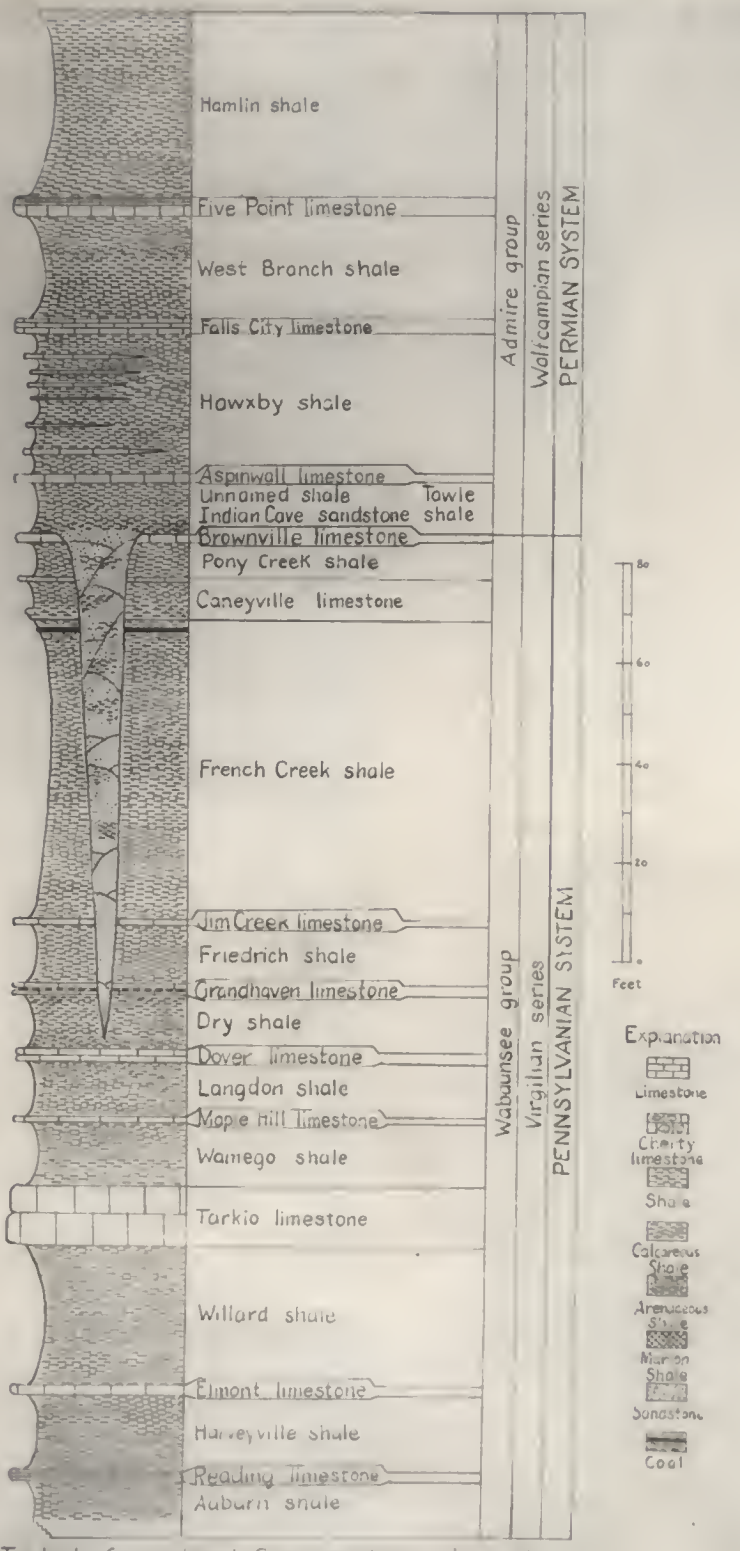

Table I. Generalized Stratigraphic section of Riley County, Kansas

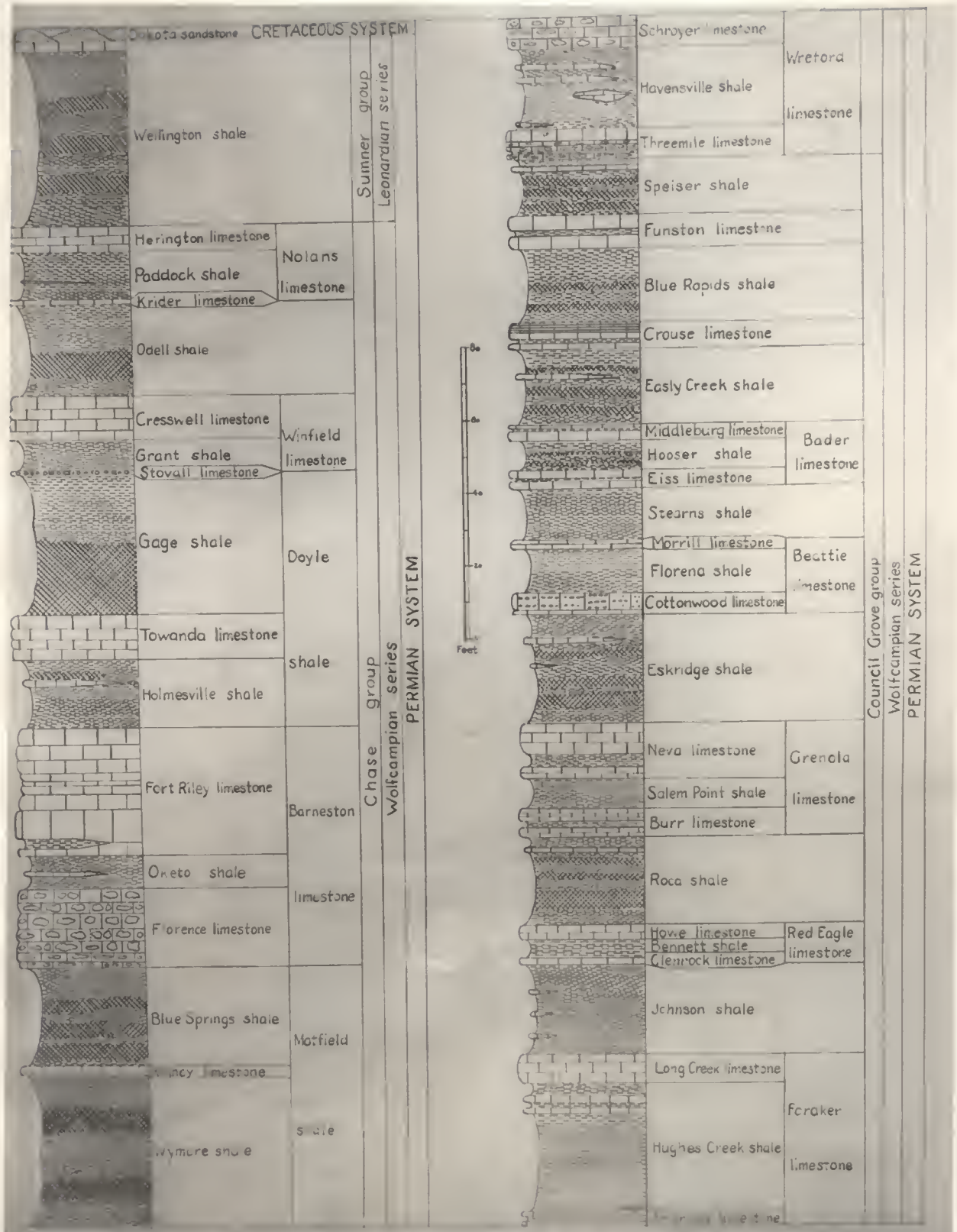

Table I (cont'd). Generalized Stratigraphic section of Riley County, Kansas

STRATIGRAPHY OF THE PENNSYLVANIAN SYSTEM

Introduction

The Virgil series was named by Moore (1932, p. 279). It includes the strata between the unconformity that is the upper boundary of the Missouri series and the local unconformity at the base of the Permian system. The Virgil series is composed of the Douglas, Shawnee and Wabaunsee groups of which only a portion of the Wabaunsee group crops out in Riley County, Kans.

The Wabaunsee group was named by Prosser (1926, p. 600). Moore (1936, p. 200) later applied the name to the beds above the top of the Topeka limestone and below the unconformity at the base of the Towle shale, the basal formation in the Permian system.

A thickness of about 190 feet of rocks of the Wabaunsee group is (Table I) present in Riley County. The outcrop area is in the eastern part of the county and extends about 3 miles east and 3 miles south from Zeandale, Kans. The outcrops in this area are a part of an anticline over the buried Nemaha ridge. The Wabaunsee group is composed predominantly of thick shale interbedded with thin limestones.

Auburn Shale

Naming of the Formation. The Auburn shale (Table I) was named by Beede (1898, p. 30). The type locality is in the vicinity of Auburn in Shawnee County, Kans. Good exposures occur along

Wakarusa Creek near the northeast corner of sec. 26, T. 13, R. 14 E., a short distance southeast of Auburn.

The Auburn shale was formerly designated as the top bed of the Cumpirey shale member of the Wabaunsee formation. The Auburn shale was redefined by Condra (1927, p. 70) and that redefinition is followed here. The Auburn shale lies above the Wakarusa limestone and below the Reading limestone.

Areal Distribution. Outcrops of the Auburn shale in Riley County are restricted to the eastern part (Plate I). It is the oldest stratigraphic unit cropping out in the county. The formation is well exposed along Deep Creek in the northwest portion of sec. 27, T. 10 S., R. 9 E. Another representative outcrop occurs in a ditch near the center of the W½ sec. 32, T. 10 S., R. 9 E.

Description of the Formation. Only the upper part of the Auburn shale is exposed in Riley County. It is clay shale, with some silt, and is noncalcareous in some zones, calcareous in others. This shale is gray to gray-green and weathers gray. Its structure ranges from laminated to blocky. There are some limonite and carbon stains on the bedding planes. A thin calcareous lens is present in the upper portion of an outcrop found in the center of the W½ sec. 32, T. 10 S., R. 9 E.

No fossils were found in this formation. The Auburn shale has no particularly distinguishing outcrop expression. The Auburn shale can best be identified by the presence of the Reading limestone immediately above it (For detailed description see measured sections 1 and 3).

Facies Changes in the Formation. Only two sections were measured of the Auburn shale, both in its upper part. These are located near the center of the [illegible] sec. 32, T. 10 S., R. 9 E. (Measured Section 1) and in the [illegible] sec. 27, T. 10 S., R. 9 E. (Measured Section 3). A facies change was noted even though the measured sections are within a mile of each other. The exposure in measured section 1 is the more calcareous of the two and contains a well-defined calcareous lens. The exposure in measured section 3 is clayey and noncalcareous.

Reading Limestone

Naming of the Formation. The Reading limestone (Table I) was named by Smith (1904, p. 158). The type locality is in the vicinity of Reading, Lyon County, Kans. A good exposure of this limestone is exhibited near the northwest corner of sec. 33, T. 17 S., R. 13 E. This location is one mile east and one mile north of Reading.

There has been much discussion as to the proper name for the limestone now called the Reading. At one time it was included in the Emporia limestone. The name "Reading Blue limestone" was later given it by Smith (1905, p. 180). Beede (1903, p. 30) had applied the name Nakarusa to this limestone, but Condra (1907, p. 66) later redefined the Nakarusa as the next older limestone formation. This permitted the name assigned by Smith, minus the term "blue," to be reapplied to this unit. The Reading limestone is above the Auburn shale and below the Harveyville shale.

Areal Distribution. The Reading limestone crops out along Deep Creek near the northeast corner of sec. 27, T. 10 S., R. 9 E. (Plate I). Other outcrops are present at the heads of tributaries draining into Deep Creek in the south part of sec. 22, T. 10 S., R. 9 E. and another exposure occurs above the Auburn shale in a ditch near the center of the NW¼ sec. 32, T. 10 S., R. 9 E.

Description of the Formation. The Reading limestone is hard, dense, gray and weathers tan. It is a single massive ledge in fresh exposures but weathers to irregularly sloped blocks distributed into three or four distinct zones. Limonite stains and specks are very abundant throughout the rock. The fossils observed in this limestone are: crinoid columnals, brachiopod fragments, echinoid spines, Chonetes granulifera, Derbia crassa, Fistulipora sp., some algae nodules, Bellerophon sp., fusulinids, Meekella striatocostata, Euomphalus pernodosus, Neospirifera sp., and Turritella sp. The average thickness of this limestone is about 2 feet.

The Reading limestone is easily recognized in the field by its characteristic weathering and by its stratigraphic position below the Elmont limestone (For detailed descriptions see measured sections 1 and 3).

Facies Changes in the Formation. No facies changes were noted in the Reading limestone within the limited area of its outcrop in Riley County.

Harveyville Shale

Naming of the Formation. The Harveyville shale (Table I) was named by Moore (1935). The type locality is near Harveyville, Pabaunsee County, Kans. A representative section can be seen in sec. 25, T. 15 S., R. 13 E., Osage County, Kans.

The Harveyville shale was included in the Emporia limestone as defined by Kirk and others (1930, p. 90) and Adams (1903, p. 82) placed it in the Olpe shale. Condra and Reynolds (1915, p. 18) placed the Harveyville in the Preston limestone and referred it as part of the Nemaha formation. The Harveyville shale overlies the Reading limestone and underlies the Elmont limestone.

Areal Distribution. The upper part of the Harveyville shale can usually be seen wherever the Elmont limestone is exposed (Plate I). A full section of this shale crops out beneath the Elmont limestone near the northwest corner of sec. 26, T. 13 S., R. 14 E.

Description of the Formation. The Harveyville is a clayey and slightly calcareous shale. It is gray-green and weathers light gray-green. The structure of the shale varies from thin-bedded to blocky. Occasional limonite stains occur along the bedding planes and calcareous nodules may be present in the upper portion of the formation. The shale is nonfossiliferous in Riley County. The average thickness of the Harveyville is about 15.5 feet.

Lacking distinctive features, the Harveyville shale can be distinguished from other shales in the Pennsylvanian system only by its association with the Elmont or Reading limestones (for

detailed descriptions see measured sections 1, 2, and 3).

Facies Changes in the Formation. Two sections were measured of the Harveyville shale. The only noticeable facies change is a slight reduction in thickness toward the southwest. Other features of this shale remain constant.

Elmont Limestone

Naming of the Formation. The Elmont limestone (Table I) was named by Beede (1900, p. 80). The type locality is in the city of Elmont in the northern part of Shawnee County, Kans.

The Elmont limestone was included in the Emporia limestone by Kirk (1896, p. 80) but Adams (1903) placed it in the Olpe shale. This limestone was referred as the Preston limestone by Condra and Pengeton (1915, p. 16). The Elmont limestone overlies the Harveyville shale and underlies the Willard shale.

Areal Distribution. The Elmont limestone crops out in numerous places in the southeastern part of Riley County (Plate I). The most southwestern exposure may be seen in a stream bank in the W½ NW¼ sec. 5, T. 11 S., R. 9 E. At this location, the Elmont limestone creates a small waterfall. Another good exposure occurs in a road cut in S½ W½ SW¼ sec. 27, T. 10 S., R. 9 E. Other exposures of this limestone were observed in the center of the W½ sec. 32, T. 10 S., R. 9 E. and on the east side of Deep Creek near the terrace level in secs. 27, 28, and 32, T. 10 S., R. 9 E.

Description of the Formation. The Elmont limestone is hard,

dense, blue-gray to gray and weathers gray to tan-gray. The unweathered rock is massive but weathers to large rectangular blocks. A good fracture pattern displayed in this limestone can be observed in the NW¼ NW¼ sec. 6, T. 11 S., R. 9 E. and is evident wherever the Elmont crops out in this county. A thin but persistent limonite zone occurs at the very top of the Elmont limestone and iron stains are sometimes present on the fracture planes. The fossils present are: worm burrows (?) in the top part, Marginifera sp., crinoid columnals, Amboccelia sp., Composita sp., echinoid spines, Neospirifera sp., Bellerophon sp., and brachiopod fragments. Large and small fusulinids are abundant in this formation. The average thickness of the Elmont is about 2 feet.

The distinctive characteristics of the Elmont limestone are its massiveness, blue-gray color, fracture pattern and its stratigraphic position beneath the readily recognized Tarkio limestone (For detailed descriptions see measured sections 1, 2, and 3).

Facies Changes in the Formation. There is a slight thickening of the Elmont limestone toward the southeast. The thickening amounts to only .4 foot but is the only change observed in this limestone.

Willard Shale

Naming of the Formation. The Willard shale (Table I) was named by Meade (1890, p. 31). The type locality is in the vicinity of the city of Willard, Shawnee County, Kans.

Adams (1903, p. 92) included this shale as a member of the

Olpe shale. Haworth and Bennett (1908, p. 114) erroneously placed the Willard shale below the Emporia limestone, thus putting the shale now called the Willard in the Admire shale. Condra (1927, p. 69) placed the Willard shale beneath the Terkio limestone and above the Burlingame limestone. Moore (1936, p. 22) designated this formation as overlying the Elmont limestone and underlying the Terkio limestone.

Areal Distribution. The upper part of the Willard shale is usually exposed beneath every outcrop of the Terkio limestone (Plate I). Most of the exposures of this shale are restricted to the east side of Deep Creek. An outcrop of the full thickness of the formation occurs in a stream bank in the NW¼ NW¼ sec. 3, T. 11 S., R. 9 E. There is another full outcrop exposure in a road cut in the SW¼ NW¼ NW¼ sec. 27, T. 10 S., R. 9 E. A partial section of this formation was observed in NW¼ SW¼ sec. 32, T. 10 S., R. 9 E.

Description of the Formation. The Willard shale is clayey with some silt and is usually calcareous. It is blue-gray to tan-gray and usually weathers tan. The shale is thin-bedded at the top but becomes blocky toward the base. Limonite stains are present on some of the bedding and fracture planes. There were no fossils observed in the Willard shale. The average thickness of this shale is about 23 feet.

The Willard shale can be identified in the field by its position beneath the easily recognized Terkio limestone (For detailed descriptions see measured sections 2 and 3).

Facies Changes in the Formation. Only a minor amount of thinning was noted in the most southwestern outcrops. The most

important change observed is the change from calcareous shale in southwestern outcrops to noncalcareous shale in the eastern outcrop.

Tarkio Limestone

Naming of the Formation. The Tarkio limestone was named by Calvin (1900, p. 337) and later by Condra and Bengston (1915, p. 8). The new type locality as now designated by Moore (1931, p. 289) is along Mill Creek southwest of Maple Hill, Pottawatomie County, Kans. The old type locality is located along Tarkio Creek north of Coin, Iowa.

The name "Chocolate limestone" was applied to this limestone by Swallow (1867, p. 67). Calvin (1900, p. 337) designated the Tarkio limestone from exposures in Tarkio Creek, north of Coin, Page County, Iowa. Haworth and Bennett (1908, p. 114) placed the Tarkio limestone in the Admire shale. Condra and Bengston (1915, p. 8) designated the Tarkio limestone as the topmost member in the "Nemaha limestone".

The Tarkio limestone, as now defined, overlies the Willard shale and underlies the Nemaha shale.

Areal Distribution. The Tarkio limestone forms a very prominent bench in the eastern portion of Riley County (Plate I). This limestone crops out extensively on both sides of Deep Creek. The extreme southern exposure can be seen in a stream bank in the SW¼ SW¼ sec. 5, T. 11 S., R. 8 E. Good exposures of this limestone are exhibited in the SW¼ NW¼ NW¼ sec. 27, T. 10 S., R. 9 E.; west

of Deep Creek in the NW¼ NE¼ SE¼ sec. 29, T. 10 S., R. 9 E.; at Pillsbury Crossing in NE¼ NW¼ sec. 8, T. 11 S., R. 9 E.; in a stream cut in NE¼ SW¼ sec. 8, T. 11 S., R. 9 E.; and other exposures of the formation can be seen south of Zeandale and east of Deep Creek. Benches formed by this limestone can be found on most tributaries entering along the eastern edge of the county.

Description of the Formation. The Tarkio limestone is composed of two thick limestones usually separated by a thin bed of shale. Both limestones are hard, dense, gray-orange to gray-brown and weather brown to gray-brown. The limestone layers are massive and weather to large blocks which, upon further weathering, tend to break into irregular pieces. The shale parting, when present, is silty, slightly arenaceous and calcareous. The shale bed is olive-drab and weathers tan. The shale is thin-bedded and contains limonite stains and calcareous nodules.

Large fusulinids are very abundant in this formation. Crinoid columnals are distributed throughout the two limestones and other fossils present are Axophyllum rude, Lophophyllum proliferum, echinoid spines, Composita sp., and a few algal nodules. The average thickness of the limestone is about 12 feet.

The Tarkio limestone forms the only really prominent bench among the Pennsylvanian limestones cropping out in this county. The lower limestone bed forms a conspicious bench on many hillsides but the upper limestone erodes farther back and is usually concealed beneath colluvium and soil. The peculiarity of erosion creates the impression that only one limestone is present in the Tarkio. Large blocks of the lower Tarkio limestone often slump

over the face of the Pillsbury shale.

The Terkio limestone is easily recognized by its thickness, abundance of large fusulinids, and a cocoa-brown color (for detailed descriptions see measured sections 2 and 3).

Facies changes in the formation. The thickness of the Terkio limestone at Pillsbury Crossing in the W½ NW¼ sec. 5, T. 11 S., R. 9 E. is 14.5 feet. Another exposure of this limestone, with the shale parting absent, occurs in a road cut in the SW¼ NW¼ SE¼ sec. 27, T. 10 S., R. 9 E. and is 11.2 feet thick. The thickening of the Terkio limestone toward the southwest is about 3 feet.

Wamego Shale

Naming of the formation. The Wamego shale (Table I) was named by Condra and Reed (1943, p. 42). The type locality is the bluffs north of U. S. Highway No. 40, 4 miles west of Wamego, Pottawatomie County, Kans.

Haworth and Bennett (1908, p. 114) included shale now known as Wamego in the Admire shale. This shale was named the Pierson Point by Condra (1927, pp. 74, 80), and was part of the McKissick Grove shale. Condra, Moore, and Dunbar (1932, p. 17) assigned the Pierson Point shale as part of the McKissick shale. This classification and nomenclature was never accepted by Moore (1935, p. 232). The use of the name, Wamego shale, in place of Pierson Point shale, was introduced by Condra and Reed (1943, p. 42). This nomenclature has generally been accepted in this region.

Areal Distribution. The Bonego shale crops out in numerous places south and east of Acosdale (Plate I). Usually, wherever the Terkio limestone is present, a part or all of the Bonego shale can be seen. Good exposures of the Bonego shale can be observed in a road cut in [illegible], sec. 27, T. 13 N., R. 8 E.; in a ditch in the [illegible] sec. 22, T. 13 N., R. 9 E.; and in a road cut in [illegible] sec. 4, T. 11 N., R. 9 E.

Description of the Formation. The Bonego shale is clayey to silty and is noncalcareous in the northeastern outcrop area but is calcareous elsewhere in the county. It is tan-gray to blue-gray and weathers tan to tan-gray. Its structure ranges from thin-bedded to blocky with numerous limonite-stained zones and plates present in this shale. Carbon stains were observed on some of the bedding planes. No fossils were found in this formation. The average thickness of this formation is about 17 feet.

The Bonego shale can be recognized most readily by limonite plates on the weathered surface and by the presence of the Terkio limestone beneath it (For detailed description see measured sections 2 and 3).

Facies Changes in the Formation. Only minor thickening of the Bonego shale toward the northeast was observed in Riley County. The shale also changes from calcareous to noncalcareous toward the northeast.

Maple Mill Limestone

Naming of the Formation. The Maple Mill limestone (Table I) was named by Condra (1927, p. 99). The type exposure is along Mill Creek southeast of Maple Mill, Pawnee County, Nebr.

The limestone, now known as the Maple Mill, was included in the Cedaria limestone by Adams (1903, p. 39) and in the Admire shale by Dewert and Bennett (1907, p. 114). Condra (1927, pp. 74, 99) named this limestone the Maple Mill and referred it the McKissick Grove shale. Condra, Moore and Gunter (1935, p. 19) again placed this limestone as part of the McKissick shale although this classification later was rejected by Moore (1936, p. 233).

Areal Distribution. The Maple Mill limestone does not form a prominent bench and its outcrops, therefore, are relatively inconspicuous (Plate I). It is present above the Turkic limestone south of Verndale but is generally concealed beneath the unconsolidated mantle. Good exposures of the Maple Mill limestone were noted in a road cut in the NW¼ NE¼ NE¼ sec. 27, T. 10 N., R. 9 E.; in a tributary of Deep Creek in the SW¼ NW¼ SE¼ sec. 30, T. 10 N., R. 9 E.; and in a stream bank in the NW¼ sec. 8, T. 11 N., R. 9 E.

Description of the Formation. The Maple Mill limestone is gray to gray-brown and weathers tan. It is hard, massive, and the upper part weathers into irregular plates. This limestone shows a tendency to fracture at an angle of nearly 30 degrees from the vertical plane. Limonite stains are common on weathered surfaces.

small and large fusulinids are abundant in the Maple Hill. Crinoid columnals, Archocoelia sp., echinoid spines, and brachiopod fragments were also observed in the Maple Hill. The thickness of this limestone is about 1 foot.

Although this formation forms only a small and usually indistinct bench, it is easily recognized in the field by its thickness, massiveness, abundance of fusulinids and light-gray color (For detailed descriptions see measured sections 3, 4, and 5).

Facies Changes in the Formation. The only change in the Maple Hill limestone, and it is a minor one, is a thickening facies toward the southwest.

Langdon Shale

Naming of the Formation. The Langdon shale (Table I) was named by Condra and Reed (1943, pp. 42-44). The type locality is along the bluffs of the Missouri River Valley southeast of Langdon, Mo., or northwest of Craig, Mo.

The shale here identified as the Langdon, was included as a part of the Emporia limestone by Adams (1903, p. 82). Haworth and Bennett (1908, p. 114) included it in the Admire shale and Condra (1927, pp. 74, 91) named this shale Langdon and referred it to the McIlrick Grove shale. Condra, Moore, and Dunbar (1932, p. 18) retained the Table Creek shale as a member of the McIlrick shale although Moore did not accept this classification. Condra and Reed (1943, pp. 43, 44) changed the name from Table Creek to Langdon shale which classification is generally accepted.

Areal Distribution. The Langdon shale can be observed along tributaries east of Deep Creek (Plate I). A good section of this shale is exhibited in a stream bank in the NE¼ NE¼ SE¼ sec. 32, T. 10 S., R. 9 E. Another section typical of this shale can be observed in a road cut in the SW¼ NW¼ sec. 27, T. 10 S., R. 9 E.

Description of the Formation. The Langdon shale is composed of clay and silt, and is usually noncalcareous but becomes calcareous in the southwestern part of the outcrop area. The color ranges from blue-gray to gray-green and the shale generally weathers to gray-green or tan-gray. The structure varies from blocky to thin-bedded. Limonite stains and plates are present in most of the exposures. No fossils were observed in the Langdon shale in Riley County. The average thickness of this limestone is about 11 feet.

The Langdon shale can best be identified in the field by its stratigraphic position beneath the easily recognized Dover limestone and above the Maple Hill limestone (For detailed descriptions see measured sections 3, 4, 5, and 6).

Facies Changes in the Formation. The Langdon shale thins from 13.6 feet in its eastern outcrops to 8.5 feet toward the west. As its thickness decreases, the shale changes from noncalcareous to calcareous.

Dover Limestone

Naming of the Formation. The Dover limestone (Table I) was named by Beede (1900, p. 31). The type locality is in the vi-

cinity of Dover, Shawnee County, Kans.

Adams (1903, p. 62) included the limestone now known as the Dover as part of the Emporia limestone and Haworth and Bennett (1908, p. 114) placed it in the Admire shale. Condra (1927, pp. 74, 80) referred the Dover limestone as part of the McKissick Grove shale. Condra, Moore, and Dunbar (1932, p. 18) placed the Dover in the McKissick shale. This classification later was rejected by Moore (1933, p. 236) who reassigned the original name, Dover limestone.

Areal Distribution. The Dover limestone forms a small hillside bench east of Deep Creek (Plate I). It forms numerous knolls in that area and crops out near the heads of most tributaries flowing into Deep Creek from the west. Small knolls and hillside benches formed by this limestone occur south of Pillsbury Crossing.

Description of the Formation. The Dover limestone is usually soft and argillaceous in the upper and lower parts but is quite hard and dense in the middle part. This limestone is gray-green to gray and weathers to light gray but locally there is a brown layer in the middle part. The limestone is massive in fresh cuts but becomes blocky to nodular when weathered. Weathered surfaces are usually covered with small plates and nodules, and iron stains may be present on joint planes. Large fusulinids are the most conspicuous fossils in the formation. They are very abundant and are scattered throughout the limestone. Small fusulinids are also present and algae are quite abundant. Other fossils noted in the Dover are Aviculopecten occidentalis, Keokella striatocostata,

Neospirifera sp., Rhombopora sp., crinoid columnals, echinoid spines, Dictyoclostus portlockianus, Ambocoelia sp., Juresania nebrascensis, Chonetes granulifera and Derbyia crassa. The average thickness of the Dover limestone is about 2.5 feet.

The Dover limestone is easily recognized by the abundance of large fusulinids and by the unusual number of algal nodules. The light gray color of the Dover limestone readily distinguishes it from the brown Tarkio limestone (For detailed descriptions see measured sections 3, 4, 5, and 6).

Facies Changes in the Formation. The thickness of the Dover limestone varies little over the county. Brown zones are developed locally in this limestone. Fusulinids are not as abundant toward the south as they are in the northern exposures of the formation.

Dry Shale

Naming of the Formation. The Dry shale (Table I) was named by Moore (1935, pp. 22, 236). The type locality is along Dry Creek, southwest of Emporia, Kans., in sec. 5, T. 20 S., R. 11 E.

The bed now known as the Dry shale was included in the Emporia limestone by Adams (1903, p. 32). Haworth and Bennett (1908, p. 114) referred this unit to the Admire shale and Moore (1935, p. 236) defined it as the shale underlying the Grandhaven limestone and overlying the Dover limestone.

Areal Distribution. The Dry shale crops out in the southeastern part of Riley County only (Plate I). Exposures of the formation are not numerous but the following are considered to be

representative: a road cut in the [illegible] sec. 5, T. 11 S., R. 9 E.; a stream bank in the [illegible] sec. 31, T. 10 S., R. 9 E.; and a stream bank in the [illegible] sec. 27, T. 10 S., R. 9 E.

Description of the Formation. The Dry shale is silty and calcareous in the lower part and clayey and noncalcareous in the upper part. It is gray-green to a yellow-gray in fresh exposures and weathers tan to yellow in the lower part and gray in the upper part. This shale is thin-bedded and there are a few calcareous nodules and limonite stains present on bedding planes. The Dry shale is nonfossiliferous in Riley County. The average thickness of this shale is about 11 feet.

The Dry shale can be recognized by its position above the easily identified Dover limestone and by its yellow color when weathered (for detailed descriptions see measured sections 4, 5, 6, and 9).

Facies Changes in the Formation. No facies changes were observed in the Dry shale in this county.

Grandhaven Limestone

Naming of the Formation. The Grandhaven limestone (Table I) was named by Moore (1931, p. 237). The type locality is in sec. 31, T. 13 S., R. 14 E. near Grandhaven, Shawnee County, Kans.

The limestone, now called the Grandhaven, was included as part of the Emporia limestone by Adams (1903, p. 32). Haworth and Bennett (1904, p. 114) referred this limestone as part of the Admire shale. Moore defined the Grandhaven as the limestone

occurring above the Dry shale and below the Friedrich shale.

Areal Distribution. The Grandhaven limestone caps most of the hills east, west, and south of Deep Creek (Plate I). This limestone was studied in the following places: a stream bank in the SW¼ SE¼ sec. 28, T. 10 S., R. 9 E.; a stream bank in the NE¼ NE¼ sec. 28, T. 10 S., R. 9 E.; a road cut in the E½ NE¼ sec. 6, T. 11 S., R. 9 E.; a stream bank in the NE¼ NE¼ sec. 31, T. 11 S., R. 9 E.; and in a road cut in the NE¼ NW¼ sec. 30, T. 10 S., R. 9 E.

Description of the Formation. The Grandhaven limestone generally consists of two limestones separated by a shale. The limestones are hard, dense, and somewhat argillaceous. They are brown to gray and weather light brown to light gray. Both of the limestones are massive and usually weather to irregular blocks or small plates. The intervening shale bed is usually clayey, calcareous, and gray-green. Fossils observed in the Grandhaven are crinoid columnals, Derbyia sp., Echinoconchus sp., small and large fusulinids and Chonetes granulifera. The average thickness of the Grandhaven limestone is about 2 feet.

The Grandhaven can easily be recognized in the field by its thickness, color, and stratigraphic position above the readily identified Dover limestone (For detailed description, see measured sections 5, 6, 7, and 8).

Facies Changes in the Formation. As the measured sections show, at least two atypical sections of the Grandhaven occur in Riley County. These exposures are located in a stream bank in the NE¼ SW¼ sec. 4, T. 11 S., R. 9 E., and in a road cut in the NE¼

sec. 6, T. 11 S., R. 9 E. The upper beds included in the Dry shale are thought to be a transitional stage of the Grandhaven limestone. This conclusion is suggested by :

1. The absence of the lower bed of the Grandhaven limestone.

2. The presence of typical Grandhaven fossils in this shale zone.

3. The thickness of the shale zone compared with that of the lower Grandhaven limestone.

4. The extremely calcareous nature of the shale zone and the presence of thin limestone lenses in it.

Friedrich Shale

Naming of the Formation. The Friedrich shale (Table I) was named by Moore (1936, p. 230). The type locality is along Friedrich Creek in sec. 6, T. 23 S., R. 11 E., Greenwood County, Kans.

The shale, here designated as the Friedrich, was included in the Admire shale by Adams (1903, p. 62). Condra (1927, p. 14, 81) renamed the beds between the Dover and Brownville limestones as the Pony Creek shale, and referred it to the McKissick Grove shale. Condra, Moore, and Dunbar (1930, p. 10) included this shale as part of the McKissick shale. During the same year, Moore and Condra (1932) placed the Friedrich shale in the French shale. Moore (1936) assigned the name, Friedrich shale, to the shale between the Grandhaven and Jim Creek limestones which is the presently accepted practice.

Areal Distribution. The Friedrich shale is represented in

Riley County by erosional remnants, which are only 2 or 3 feet thick and lie on top of the Grandhaven limestone (Plate I). A full section of this shale was observed in a stream bank in the SE¼ NW¼ sec. 4, T. 11 S., R. 9 E. and the upper part of the formation was found cropping out in a stream bank in NW¼ NW¼ sec. 10, T. 10 S., R. 9 E.

Description of the Formation. The Friedrich shale is clayey and varies from calcareous to noncalcareous. It is gray-green to gray and weathers tan to tan-gray. The upper half of the shale has a very yellow appearance on the weathered surface. The structure of the shale is thin-bedded to blocky. Calcareous nodules and limonite stains occur locally in the formation. No fossils were found in the Friedrich shale exposed in Riley County. The average thickness of this shale is about 12 feet.

The Friedrich shale can best be identified by its stratigraphic position beneath the persistent Jim Creek limestone and overlying the Grandhaven limestone (For detailed descriptions see measured sections 6, 7, and 8).

Facies Changes in the Formation. The Friedrich shale is calcareous in the western part of its outcrop area, but becomes noncalcareous on the eastern part.

Jim Creek Limestone

Naming of the Formation. The Jim Creek limestone (Table I) was named by Moore (1935). The type locality is on Jim Creek in sec. 23, T. 7 S., R. 11 E., Pottawatomie County, Kans.

The limestone here designated as the Jim Creek was first listed as part of the Adaire shale by Ideas (1903, p. 32). Condra (1927, pp. 74, 81) placed this limestone in the Pony Creek shale and referred it as part of the McCrosick Grove shale. Condra, Moore and Dunbar, in 1932, referred the layer to the McCrosick shale. Moore and Condra, later in 1932, stated that the name Jim Creek was erroneously applied to a limestone member in the Caneyville limestone, therefore, they listed the Jim Creek limestone as a member in the French shale. Moore, in 1934, raised the Jim Creek limestone to the rank of a formation. This definition of the Jim Creek is now generally accepted.

Areal Distribution. The Jim Creek limestone was observed in two exposures in this county (Plate I). The first outcrop is exhibited in a stream bank in [illegible] sec. 4, T. 11 S., R. 9 E.

Description of the formation. The Jim Creek limestone is hard and dense. Its color is gray with a purplish tint and it weathers gray. A brown limonite zone develops at the top. The unweathered limestone is massive but it weathers into blocks which further decompose to small chips. Fossils noted in the Jim Creek limestone are: Chonetes granulifera, crinoid columnals, Fenestella sp., Dictyoclostus americanus, Aviculopinna peracuta, Composita sp., and fusulinids. The average thickness of the formation is about 1.1 feet.

This limestone can readily be identified by its thickness, massiveness, purplish tint, and variety of fossils (For detailed description see measured section 8).

Facies Changes in the formation. No noteworthy facies changes

were observed in the Jim Creek limestone in Riley County.

French Creek Shale

Naming of the Formation. The French Creek shale (Table I) was named by Moore (1935). The type locality is along French Creek, which is located in northeastern Pottawatomie County, Kans.

The shale, now called the French Creek shale, was included as part of the Admire shale by Adams (1903, p. 32). Condra (1927, pp. 74, 81) redefined the beds between the Dover and Brownville limestone as the Pony Creek shale, and listed it as part of the McCasick Grove shale. Condra, Moore, and Dunbar (1938) placed the shale, here called the French Creek, in the McCasick shale. Later in the same year, Moore and Condra (1932) designated this shale as the upper part of the French shale. Moore (1935) named this unit the French Creek shale. The French Creek shale overlies the Jim Creek limestone and underlies the Cloudy Ville limestone.

Areal Distribution. Only two partial exposures of the French Creek shale were observed in Riley County (Plate I). One exposure of this shale was observed in the bank of a small stream in the NW¼ NE¼ sec. 31, T. 10 S., R. 9 E. The other exposure is exhibited in a stream bank in the SE¼ SW¼ sec. 4, T. 11 S., R. 9 E.

Description of the Formation. The French Creek shale is composed of noncalcareous, slightly arenaceous clay. This shale is gray to tan-gray and weathers tan to yellow. The structure of the unit varies from thin-bedded to blocky. Limonite stains are

abundant on the bedding and fracture planes and limonite nodules and plates are present on the weathered surface. Carbon stains are locally present in a part of the French Creek and an 0.4 foot impure coal lens occurs near the top. The coal bed has been called the Lorton coal and is overlain by a very calcareous, fossiliferous shale. Derbyia crassa predominates in this calcareous zone. The average thickness of the exposed part of the French Creek shale is about 20 feet. This unit, in its full thickness, was not found in Riley County.

This shale can be identified by the persistent coal bed in the top and its stratigraphic position above the easily recognized Jim Creek limestone (For detailed descriptions see measured sections 8 and 9).

Facies Changes in the Formation. Because of limited outcrops, no significant facies changes were noted in the French Creek shale in the area investigated.

Caneyville Limestone

Naming of the Formation. The Caneyville limestone (Table I) was named by Moore (1935). The type locality is sec. 11, T. 32 S., R. 8 E. It was named from the Caneyville Township, Chautauqua County, Kans.

The limestone, here designated as the Caneyville limestone, was included in the Admire shale by Adams (1903, p. 42). Bowen (1918, p. 133) gave the name of Grayhorse limestone to the upper member of the Caneyville limestone. Beds of limestone and shale,

now known as part of the Caneyville limestone, were placed in the McKissick Grove shale by Condra (1927, pp. 74, 91). A limestone layer, the Nebraska City, was classified by Condra (1927, p. 116) as a subdivision of the Pony Creek shale and was later reclassified by Moore (1935) as the lower member of the Caneyville limestone. Condra, Moore and Dunbar (1932) listed the Caneyville limestone as part of the McKissick shale. Moore (1935) then named the beds from the base of the Nebraska City limestone to the top of the Grayhorse limestone of the Caneyville limestone, which definition is now followed. The Caneyville limestone overlies the French Creek shale and underlies the Pony Creek shale.

Areal Distribution. The Caneyville limestone occurs only in the western and southwestern part of the Pennsylvanian outcrop area of Riley County (Plate I). A full exposure of the limestone can be observed in a stream bank in the NW¼ NE¼ sec. 31, T. 10 S., R. 9 E. and a part of this limestone is exposed in a stream bank in the SE¼ NW¼ sec. 6, T. 11 S., R. 9 E.

Description of the Formation. The Caneyville limestone, as observed in Riley County, Kans., is composed of a limestone underlain by a shale.

The shale is clayey, calcareous, thin-bedded, gray and weathers tan-gray. There is an 0.5 foot calcareous zone near the middle of the unit and a thin carbonaceous zone, which contains wood fragments at the top. Limonite stains are abundant on many of the bedding planes. Limonite nodules and concretions covered with fine flakes of mica appear on weathered surfaces.

The limestone, overlying the shale, is hard, tan to brown,

and weathers tan-gray. It is massive and weathers blocky. Limonite nodules and stains are abundant and a few clay balls are present. Fossil fragments are also abundant. The average thickness of the Caneyville limestone in Riley County is about 0.8 feet.

The Caneyville limestone can be identified by its position above the Lorton coal bed in the Pony Creek shale, by the fossiliferous zone at its base, and by stratigraphic position beneath the easily identified Brownville limestone (for detailed description see measured section 9).

Facies Changes in the Formation. No facies changes were noted in the Caneyville limestone in this region.

Pony Creek Shale

Naming of the Formation. The Pony Creek shale (Table I) was named by Condra (1927, p. 81) but was placed in its present stratigraphic position by Moore (1931). The type locality is along Pony Creek between the Kansas-Nebraska boundary and a point 2 miles south of Falls City, Nebr.

The shale here designated as Pony Creek was first placed in the Admire shale by Adams (1903, p. 32). Condra (1927, pp. 74, 81) defined the Pony Creek shale to include the beds from the top of the Dover limestone to the base of the Brownville limestone, and referred it as part of the McMissick Grove shale. Condra, Moore, and Lumbar (1932, p. 18) listed the Pony Creek as part of the McMissick shale. This classification was later rejected by Moore (1931, p. 243) at which time he reverted the shale to the

position between the Cone ville and Brownville limestones.

Areal Distribution. Only two outcrops of the Pony Creek shale were noted in Riley County, Kans. (Plate I). This shale can be observed in a small tributary in the [illegible] sec. 31, T. 10 S., R. 9 E. and in a road cut in the [illegible] sec. 7, T. 11 S., R. 9 E. It is known to be present but is covered with slope wash in the [illegible] sec. 6, T. 11 S., R. 9 E.

Description of the Formation. The Pony Creek shale is silty, calcareous, and varies from blue-grey to tan in color. It is thin-bedded and has numerous limonite stains on the bedding planes. No fossils were found in this shale. Its average thickness is about 7 feet.

The Pony Creek shale can best be identified in the field by its position beneath the easily recognized Brownville limestone (For detailed descriptions see measured sections 9 and 10).

Facies Changes in the Formation. No important facies changes were observed in the Pony Creek shale in Riley County.

Brownville Limestone

Naming of the Formation. The Brownville limestone (Table I) was named by Condra and Ferguson (1915, p. 17). The type locality is in the bluffs of the Missouri River just south of Brownville, Nemaha County, Nebr.

The limestone, here known as Brownville, was first included as part of the Admire shale by Adams (1903, p. 72). It is now

classed, by Moore (1933), as the youngest unit of the Pennsylvanian system which classification has gained general acceptance. The Brownville limestone overlies the Pony Creek shale and underlies the Towle shale.

Areal Distribution. The Brownville limestone is exposed in the bank of a small stream in the [illegible] sec. 31, T. 10 S., R. 9 E. (Plate I). Another exposure of this limestone is exhibited in a road cut in the [illegible] sec. 7, T. 11 S., R. 8 E. This limestone is known to be present but covered by slope wash in the [illegible] sec. 6, T. 11 S., R. 8 E.

Description of the formation. The Brownville limestone is medium hard and slightly argillaceous. It is tan to brown and weathers gray. This limestone is blocky and weathers to nodules. Numerous limonite stains are present on fracture planes. Chonetes granulifera, crinoid columnals, and Marginifera wabaunsensis are abundant in this limestone and Dictyoclostus sp., Lissochonetes geinitzianus, and Ambocoelia sp. occur less numerously. The average thickness of the Brownville limestone is about 1.5 feet.

The limestone is easily recognized by its thickness, color, and content of fossils (For detailed descriptions see measured sections 9 and 10).

Facies Changes in the Formation. The Brownville limestone was found to thin toward the south in this area.

STRATIGRAPHY OF THE PERMIAN SYSTEM

Introduction

The Permian system, in descending order, consists of the Guadalupian, Leonardian, and Wolfcampian series. Only the basal part of the Leonardian series is represented locally in Riley County, but outcrops of the Wolfcampian series are present over most of the county. The strata from the Towle shale to the Pellington shale, inclusive, are part of the Permian system. The Indian Cave sandstone is locally present at the base and marks the unconformity between the Permian and Pennsylvanian systems. This disconformity, discovered by Moore and Ross (1933, p. 100) is decipherable in eastern Riley County.

The Wolfcampian series (Table I), in descending order, consists of the Chase, Council Grove, and Admire group. It includes, in part, the formations that were once listed by Cragin (1896, pp. 3, 5) in the "Pig Blue" series. The "Pig Blue" series, so defined, contained all formations of the Wolfcampian series and the Leonardian series is defined as the top of the Nolans formation.

Admire Group. Adams (1903, p. 62) placed the units here included in the Admire group in the Admire shale. Condra (1927, pp. 71, 82) adopted Adam's term, the Admire shale, for those beds between the Americus and Brownville limestones. Moore (1929, p. 43) defined the "Admire shale" as to include the Willard shale, Tarkio limestone, McFisslck Grove shale, and the Admire shale

(restricted). Later, Moore (1932) restricted the Admire shale to the strata between the Brownville and Americus limestones. Condra (1932, pp. 8 and 9) assigned to the Admire group the same stratigraphic units as defined in 1927.

The Admire group, as the term is here used, includes the following formations (descending order): Hamlin shale, Five Point limestone, West Branch shale, Falls City limestone, Hawxby shale, Aspinwall limestone, and Towle shale.

Towle Shale

The Towle shale (Table I) was named by Moore and Condra (1932). The type locality is at Towle farm, two miles south and three miles west of Falls City, in the SW¼ sec. 20, T. 1 N., R. 16 E., Richardson County, Nebr. The Indian Cave sandstone member and an unnamed shale member, which overlies the sandstone, comprise the Towle shale

Indian Cave Sandstone Member

Naming of the Member. The Indian Cave sandstone (Table I) was named by Moore and Moss (1933, p. 100). The type locality is near Indian Cave, Nebr. The maximum thickness of this unit so far encountered, 230 feet, was recorded in Pottawatomie County by Berned and Chelikowsky (1948, p. 355).

Areal Distribution. The Indian Cave sandstone, a channel deposit, is only locally present although exposures are numer-

ous in southeastern Riley County (Plate I). A typical exposure of the Indian Cave was observed in a road cut in NE¼ SW¼ SE¼ sec. 30, T. 10 S., R. 9 E. The sandstone, in this exposure, is in contact with the Jim Creek limestone. Another exposure is well displayed in a drainage ditch in the NW¼ NE¼ sec. 9, T. 11 S., R. 9 E. and in this outcrop the sandstone rests on the French Creek shale. An outlier of the Indian Cave sandstone occurs in the NE¼ SW¼ sec. 28, T. 10 S., R. 9 E. At this place the sandstone rests on the lower part of the Dry shale. In the SW¼ NE¼ NE¼ sec. 31, T. 11 S., R. 9 E., the Indian Cave overlies the lower part of the Friedrich shale as it does also in the NE¼ NE¼ sec. 28, T. 10 S., R. 9 E. and to the north of this location it cuts below the Grandhaven limestone.

Description of the Member. The Indian Cave sandstone is a fine-grained quartz and mica sand cemented with iron oxide and possibly calcium carbonate. As described by Jewett (1941 p. 41):

> The quartz grains are extremely angular and range from approximately 0.03 mm. to 0.175 mm. size. The mica flakes are larger and make up about 0.25 of 1 percent of the whole. The quartz grains are deeply stained with iron oxide.

The sandstone is cross-bedded and contains numerous limonite concretions. It varies from an arenaceous shale in part, to a loosely cemented sandstone with an occasional firmly cemented bed. Small ripple marks, fossil wood, and leaves are sometimes found in this member and carbon and limonite stains are common in its upperpart. The maximum thickness of the Indian Cave sandstone is about 75 feet.

This member can be identified by its distinctive and nonconformable position in older units (for detailed descriptions see measured sections 7 and 8).

Unnamed Shale Member

Areal Distribution. The unnamed shale underlies the Aspinwall limestone and overlies either the Indian Cave sandstone or the Brownville limestone (Table I).

Outcrops of this shale were studied in the eastern part of Riley County where it extensively crops out most (Plate I). A well exposed section was observed in a drainage ditch in the NW¼ NE¼ sec. 9, T. 11 S., R. 9 E. in which the Indian Cave sandstone grades up into the unnamed shale member. It is difficult to determine the exact contact between these two units. Another exposure of the shale member can be seen in a ditch in the NE¼ NE¼ sec. 31, T. 10 S., R. 9 E. The Indian Cave sandstone is absent at this location and the shale rests directly upon the Brownville limestone.

Description of the Member. This shale is usually clayey, varies from noncalcareous to calcareous, is tan-gray to blue-gray, and usually weathers tan. The shale is thin-bedded and occasionally contains one or more thin calcareous zones. A thin impure coal lens sometimes occurs near the base. Limonite stains and nodules are usually present on weathered surfaces. The thickness of the unnamed shale member in Riley County, varies from 6.9 feet to 11.2 feet.

This shale is best identified in the field by its stratigraphic position beneath the Aspinwall limestone (For detailed descriptions see measured sections 8, 9, and 10).

Facies Changes in the Member. The thickness of the Towle shale is variable and is dependent on the presence or absence of the Indian Cave sandstone.

Aspinwall Limestone

Naming of the Formation. The Aspinwall limestone (Table I) was named by Condra and Bengston (1915, pp. 9, 17, 29). The type locality is at Aspinwall, Nebr.

Condra (1927, pp. 73, 82, 89) assigned all beds between the Falls City and Brownville limestones to the Aspinwall shale. Moore and Condra (1932) named the intervening shale the Hawxby and restored the name Aspinwall to the lower limestone. Condra (1935, p. 9) designated the Aspinwall limestone formation as underlying the Hawxby shale and overlying the Towle shale.

Areal Distribution. The Aspinwall limestone crops out in the southeastern part of Riley County (Plate I). All of the observed outcrops were found in the area southwest of Leandale, Kans. A small knoll located in the NW¼ SW¼ sec. 29, T. 10 S., R. 9 E., is capped by the Aspinwall limestone and another good exposure of this limestone was observed near the top of an isolated hill in the NW¼ NE¼ sec. 31, T. 10 S., R. 9 E. The Aspinwall is present, but under cover, in the NE¼ SW¼ NW¼ sec. 30, T. 10 S., R. 9 E. and in the NW¼ NW¼ sec. 9, T. 11 S., R.

9 S.

Description of the Formation. The Aspinwall limestone is hard, somewhat crystalline, and locally exhibits a brecciated appearance. It is gray-orange and weathers gray. This limestone is massive and weathers blocky. Limonite stains and nodules, clay zones, and clay balls are distributed throughout the limestone. Fossils found in the Aspinwall limestone are crinoid columnals, Pellicropion sp., and Pleurophorus albequus. The thickness of the Aspinwall limestone in Riley County varies from 1.1 feet to 1.7 feet. The Aspinwall limestone makes a small hillside bench.

This limestone is easily distinguished from the Brownville and Falls City limestones by its massiveness and the presence of small clay balls and limonite nodules (For detailed descriptions see measured sections 8, 9, and 10).

Facies Changes in the Formation. Because exposures are so few, it is difficult to determine facies changes in the Aspinwall limestone but the unit appears to diminish in thickness toward the south.

Nawaby Shale

Naming of the Formation. The Nawaby shale (Table I) was named by Moore and Condra (1932). The type locality of the shale is the Nawaby farm in the NE¼ sec. 7, T. 4 N., R. 15 E., Nemaha County, Nebra. This shale overlies the Aspinwall limestone and underlies the Falls City limestone.

Areal Distribution. The Hawxby shale is well exhibited in many exposures in the southeastern part of Riley County (Plate I). A good exposure of this shale was observed in a road cut in the [illegible] sec. 3, T. 11 S., R. 9 E. and another is exhibited in a road cut in the [illegible] sec. [illegible], T. 11 S., R. 9 E. Part of the Hawxby shale crops out in a road cut in the [illegible] sec. 10, T. 11 S., R. 9 E.

Description of the Formation. The Hawxby shale is a thick shale containing numerous thin limestone lenses. The shale is clayey, varies from noncalcareous to calcareous, and is usually gray but ranges from gray-green to tan. The limestone lenses are hard, dense, massive, usually argillaceous, and are highly fossiliferous. Iron stains are present on the bedding planes of the shales and on the joint planes of the thin limestones. Fossils found in the Hawxby are Pleuropleurus albequus, Yoldia sp., Tornatella sp., Derbyia crassa, D. cymbula, Edmondia sp., Promytilus vetulus, Orthomalina subquadrata, Aviculopecten occidentalis, Pelleroplon sp., Straparollus girtyi, Pseudomonotis hawni, Euomphalus pernodosus, Leionema sp., and Worthenia sp. Pleuropleurus albequus is very abundant in most of the thin limestones. The average thickness of the Hawxby shale in Riley County is about 23 feet.

The Hawxby shale is easily recognized in the field by the presence of the thin, very fossiliferous limestones (For detailed descriptions see measured sections 10, 11, and 12).

Facies Changes in the Formation. The only facies change noted in this unit is the variation in the vertical positions of

the lenticular limestone layers. No one of them could be correlated from one cut to another.

Falls City Limestone

Naming of the formation. The Falls City limestone (Table I) was named by Condra and Reynolds (1916, pp. 9, 17, 30). The type locality is in the Lehmer quarry 2½ miles south and 1½ miles west of Falls City, Richardson County, Nebr.

Areal Distribution. Only two exposures of the Falls City limestone were observed in Riley County (Plate I). This limestone was found in a road ditch in the [illegible] sec. 9, T. 11 S., R. 9 E. and in a road cut in the [illegible] sec. 9, T. 11 S., R. 9 E.

Description of the formation. The Falls City limestone is soft, porous, and has a fibrous appearance. It is grey-brown and weathers a tan. Thin shale partings are present in this limestone and a platy zone was observed near the base. Juresania nebrascensis and Pleuronotus albequus are present in the basal part of the formation. The average thickness of the Falls City is about 2.5 feet. This limestone forms a small and poorly developed hillside bench.

The Falls City limestone is identified by its distinctive color, weathering characteristics, and by its stratigraphic position below the easily identified Five Point limestone (For detailed descriptions see measured sections 10, 11, and 12).

Facies Changes in the Formation. The two exposures of the

Falls City limestone suggest only that it thickens toward the southeast.

West Branch Shale

Naming of the Formation. The West Branch shale (Table I) was named by Condra (1927, pp. 74, 82, 89, 111, 113) from outcrops in West Branch Township, Pawnee County, Nebr. The West Branch shale overlies the Falls City limestone and underlies the Five Point limestone.

Areal Distribution. Two good exposures of the West Branch shale were observed in eastern Riley County (Plate I). West Branch shale is exhibited along a trail on the south side of a hill in the SE¼ SE¼ NW¼ sec. 30, T. 10 S., R. 9 E. A full exposure of this shale was observed in a ditch in the NE¼ NE¼ sec. 8, T. 10 S., R. 9 E. This shale is present, but covered, along the base of the escarpment in the northern portion of secs. 15, 16, 17, T. 11 S., R. 9 E. It crops out, also, along a hill capped by the Americus limestone in the NW¼ NW¼ sec. 9, T. 11 S., R. 9 E.

Description of the Formation. The West Branch shale is clayey, somewhat silty, and contains a zone of sandy shale near the middle. There is a thin massive limestone lens in the upper part and a thin sandstone lens in the middle part. This shale varies from gray through greenish-gray to gray-brown and weathers from tan-gray to tan-brown. The formation is thin-bedded and limonite stains and plates usually are present. Fossil leaves

of Neuropteris sp. and wood fragments occur in the middle part and the following invertebrate fossils were found in the thin limestone lens: Derbyia sp., Composita sp., Rhombopora sp., echinoid spines, crinoid columnals, Ambocoelia sp., and others. The average thickness of the West Branch shale is about 30 feet.

The West Branch shale can be identified in the field by its arenaceous shales which contain wood and leave fragments and by its stratigraphic position beneath the easily identified Five Point limestone (For detailed descriptions see measured sections 10 and 12).

Facies Changes in the Formation. The only obvious facies change noticeable in this shale is the absence of the thin limestone lens in the northern part of the outcrop area.

Five Point Limestone

Naming of the Formation. The Five Point limestone (Table I) was named by Moore and Condra (1932). The type locality is in Five Point Valley, near the Five Point school in sec. 23, T. 1 S., R. 15 E., Richardson County, Nebr. This location is 2 miles south and 4½ miles west of Falls City, Nebr. The Five Point limestone overlies the West Branch shale and underlies the Hamlin shale.

Areal Distribution. The Five Point forms an identifiable hillside bench west and south of Verdon, Kans., but is covered in other parts of the county (Plate I). This formation was studied in an old quarry in the center of the SE¼ sec. 30, T.

10 S., R. 9 E. and in the center of sec. 7 and in the [illegible] sec. 8, T. 11 S., R. 9 E. Low benches of this limestone are present along the face of a valley wall in secs. [illegible] and 10, T. 11 S., R. 9 E.

Description of the Formation. The Five Point limestone is hard and massive near the base but becomes platy and argillaceous in its upper part. The limestone is gray and usually weathers tan-gray. The following fossils were found in the Five Point: Chonetes granulifera, crinoid columnals and plates, Merginifera hystricula, Pleuroplorus albequus, Aviculopecten occidentalis, Rhombopora sp., Dictyoclostus americanus, D. portlockianus, Lexomena sp., Polypora sp., Archimedes rude, Intelates hemiplicatus, Rhipidomella carbonaria, Neospirifera sp., Derbyia sp., Eustedia mormoni, Composita ovata, Lissochonetes geinitzianus, and Amboccelia sp. All the fossils listed above occur in the massive portion of the formation. It is also the massive portion that forms the prominent hillside bench. The total thickness of the Five Point limestone in Riley County is 3.8 feet.

This limestone is easily identified by the massiveness, thickness, and stratigraphic position below the American limestone (For detailed description see measured section 18).

Facies Changes in the Formation. No important facies changes were noted in the Five Point limestone as it occurs in this county.

Hamlin Shale

Naming of the formation. The Hamlin shale (Table I) was named by Conars (1935, pp. 8, 9) but no type locality was specified by him. The Hamlin shale overlies the Five Point limestone and underlies the Americus limestone member of the Forster limestone. The Hamlin shale is composed of the following members in descending order: Oaks shale, the Louellens Creek limestone, and the Stine shale. The Louellens Creek limestone is absent in this county and the contact between the Oaks and Stines shales is difficult to determine.

Areal Distribution. Part of the Hamlin shale is usually present wherever the Americus limestone crops out (Plate I). The Hamlin shale is mapped south and west of Leonidale, Kans. The upper part of this shale was observed at the base of K-Hill in NW¼ NW¼ sec. 20, T. 10 S., R. 8 E. and extending south from that point for 1½ miles. The Hamlin shale is present, but covered, near the base of the valley wall in secs. 25, 26, 27, T. 10 S., R. 8 E. The upper part of the Hamlin crops out in a railroad cut in the NE¼ NE¼ sec. 7, T. 10 S., R. 9 E.

Description of the formation. The Hamlin shale is calcareous and generally silty except in the basal part which is clayey. The middle part of this shale is arenaceous. The color is grey to grey-green. The Hamlin is blocky but becomes thin-bedded toward the base. Calcareous lenses are present in its upper part. Iron stains occur along the fracture planes and limonite stains and nodules are common near the base. The

average thickness of the Hamlin shale in Riley County is about 27 feet.

The Hamlin shale can be recognized by its stratigraphic position below the Americus limestone (For detailed descriptions see measured sections 12, 13, and 14).

Facies Changes in the Formation. The only significant aspect of the Hamlin shale in Riley County is the absence of the Houclens Creek limestone member.

The Council Grove stage was named by Prosser (1900, p. 709) and include these stratigraphic units from the base of the Wreford limestone down to the Lakridge shale. The type locality is in the vicinity of Council Grove, Morris County, Kans. Beede (1922) lowered the base of the Council Grove stage to include the Neva limestone and Moore (1932) expanded the Council Grove group to the base of the Americus limestone.

The Council Grove group includes the following formations in descending order: Speiser shale, Funston limestone, Blue Rapids shale, Crouse limestone, Easly Creek shale, Eader limestone, Stearns shale, Fentic limestone, Lakridge shale, Gronola limestone, Nace shale, Red Eagle limestone, Johnson shale, and the Foraker limestone (Table I).

Foraker Limestone

The Foraker limestone (Table I) was named by Heald (1916, pp. 21-25). The type locality is near Foraker, Osage County, Okla. The initial use of this classification is credited to

Pass (1929, p. 45). The upper member of the Foraker limestone was included in the Kinsdale formation by Condra (1927), a practice not now followed.

The Foraker limestone is composed of the following members, in descending order: Long Creek limestone, Hughes Creek shale, and Americus limestone.

Americus Limestone Member

Naming of the Member. The Americus limestone (Table I) was named by Kirk (1930, p. 30). The type locality is near Americus in Lyon County, Kans.

Smith (1903) listed this limestone in the Americus limestone system. Prosser (1902, pp. 702, 737) and Adams (1903) defined the Americus as two limestones separated by a shale and underlying the Kinsdale formation. Hooser (1906, pp. 14, 32) designated this limestone unit and 125 feet of underlying beds as the Americus beds. Pass (1929, pp. 1, 203) listed the Americus limestone as the basal member of the Foraker limestone. He was followed in this by Moore (1930) who included it in the Permian system. The Americus limestone overlies the Howlin shale and underlies the Hughes Creek shale member.

Areal Distribution. The Americus limestone is exposed in numerous places south of the Kansas River in eastern Riley County (Plate I). It crops out near the base of T-Hill in the SW¼ NW¼ sec. 20, T. 10 S., R. 8 E., in a railroad cut in the SW¼ SE¼ sec. 7, T. 10 S., R. 8 E., and other exposures were

found in T. 10 S., R. 8 E., and T. 11 S., R. 9 E. along the valley walls south of the Kansas River and Deep Creek. A small knoll capped by the Americus occurs in the NW¼ NE¼ sec. 9, T. 11 S., R. 9 E.

Description of the Member. The Americus limestone consists of two limestones separated by a shale. Both limestones are hard, dense, and dark gray to blue-gray in color. The limestones are massive and weather blocky to platy. The shale parting is clayey, noncalcareous, and thin-bedded to fissile. It is black to dark gray in color. Fossils found in the limestones are: crinoid columnals, Marginifera lastricula, Derbyia crassa, Arbocoelia sp., echinoid spines, fusulinids, Pelleropton sp., Aviculopecten occidentalis, Aviculopinna persculpta, Dialina sp., and Euomphalus sp. No fossils were observed in the shale parting. The average thickness of this member is about 3 feet. The Americus limestone forms a good hillside bench bordered by numerous rounded light gray field stones marked by numerous crinoid columnals showing on weathered surfaces (For detailed descriptions see measured sections 13 and 14).

Facies Changes in the Member. There were no facies changes observed in the Americus limestone member as it occurs in Riley County.

Hughes Creek Shale Member

Naming of the Member. The Hughes Creek shale (Table I) was named by Condra (1927, pp. 94, 95, 99) and included it in the Elmdale shale. The type locality is along Hughes Creek,

Nemaha County, Nebr. Bass (1929) listed the Hughes Creek shale as the middle member of the Foraker limestone formation. Condra (1935, p. 8) accepted this classification of the Hughes Creek shale and extended it into Nebraska. The Hughes Creek shale overlies the Americus limestone member and underlies the Long Creek limestone member, both of the Foraker limestone.

Areal Distribution. The Hughes Creek shale member is exposed, or is present near the surface, south and west of Zeandale, Kans. (Plate I). Exposures occur along both sides of Deep Creek and near the base of the valley walls of the Blue and Kansas Rivers in the vicinity of Manhattan. Good exposures were studied in road cuts in SW¼ SE¼ NE¼ sec. 7, T. 10 S., R. 6 E., at K-Mill in NW¼ NW¼ sec. 20, T. 10 S., R. 6 E., and in a road cut in the NW¼ NE¼ sec. 25, T. 10 S., R. 7 E.

Description of the Member. The Hughes Creek shale is principally silty and calcareous with numerous interbedded thin, fossiliferous lenses of limestone. The shale beds are predominantly gray, but include some tan, olive drab, and black zones. The structure of the shale varies from fissile to blocky. Fossils are exceptionally abundant in the Hughes Creek shale and the following fossils can be found in most outcrops of the member: Dictyoclostus americanus, D. portlockianus, Composita subtilita, C. ovata, crinoid columnals, Marginifera fragilis, M. hystricula, Orbiculoidea missouriensis, Derbyia crassa, D. cymbula, Echinoconchus moorei, Juresania nebrascensis, Aviculopecten occidentalis, Hustedia morroni, Ambocoelia planoconvexa, and Lingula carbonaria. Fusulinids are very abundant, especially

in the shales and limestones of the upper part. The total thickness of the Hughes Creek shale is about 40 feet (For detailed descriptions see measured sections 14 and 15).

Facies Changes in the Member. No important facies changes were observed in this member of the Foraker formation.

Long Creek Limestone Member

Naming of the Member. The Long Creek limestone (Table I) was named by Condra (1927, pp. 84, 85, 88). The type locality is along the base of the valley wall of Long Creek near Auburn, Nemaha County, Nebr.

The Long Creek limestone was designated a member of the Elmdale shale by Condra (1927, pp. 84, 87, 88). Bass (1929, pp. 1-203) included the Long Creek limestone as the upper member of the Foraker limestone. Condra (1935, p. 9) extended the subdivision of the Foraker limestone made by Bass into Nebraska. The Long Creek overlies the Hughes Creek shale member of the Foraker limestone and underlies the Johnson shale.

Areal Distribution. The Long Creek limestone crops out south and west of Meadale, principally along the south branch of Deep Creek (Plate I). Other exposures were observed in the vicinity of Manhattan and for a few miles south, where the limestone forms a continuous outcrop on the east of the Kansas River valley wall. The most southerly outcrop noted in the field was formed at the base of a stream bank in the SW¼ NW¼ NW¼ sec. 12, T. 11 S., R. 7 E. Good exposures of the limestone were studied

at the following locations: In road cuts in the SW¼ NE¼ NE¼ sec. 7, T. 10 S., R. 8 E., road at the north end of E-Hill in the NE¼ NW¼ sec. 20, T. 10 S., R. 8 E., and in the NW¼ NE¼ sec. 21, T. 10 S., R. 7 E.

Description of the Member. The Long Creek limestone is soft and slightly dolomitic. It is fine grained, massive, and usually contains shale partings. It is usually tan to gray-orange and weathers tan. The shale partings are dark gray and thin-bedded. The Long Creek is very massive in a railroad cut in the NW¼ SW¼ NE¼ sec. 24, T. 10 S., R. 7 E. Fossils are rare or absent in the Long Creek. The average thickness of this limestone is about 8.5 feet.

The Long Creek limestone is identified by celestite found on the weathered field stones, the abundance of fusulinids present in the very top of the Hughes Creek shale and by its position above the easily recognized Americus limestone (for detailed descriptions see measured sections 14 and 15).

Facies Changes in the Member. There were no facies changes observed in this limestone.

Johnson Shale

Naming of the Formation. The Johnson shale was named by Condra (1927, pp. 84, 86, 87) and included in the Tindale shale (Table I). The type locality is 1½ miles north of Johnson, Johnson County, Nebr. He later abandoned the term "Tindale shale" and elevated the Johnson shale to the rank of a formation.

The Johnson shale overlies the Long Creek limestone member of the Forker limestone and underlies the Glenrock limestone member of the Red Eagle limestone.

Areal Distribution. Exposures of the Johnson shale are not numerous in Riley County and the only exposures found in the field occur in the vicinity of Manhattan (Plate I). Complete sections of the shale are exhibited in a road cut at the east end of Bluemont Hill in the SW¼ NW¼ SW¼ sec. 7, T. 10 S., R. 8 E., and in a railroad cut in NE¼ NE¼ NE¼ sec. 24, T. 10 S., R. 7 E.

Description of the Formation. The Johnson shale is a thick, silty, and calcareous shale and contains numerous thin highly calcareous lenses and limestones. It is gray-green and olive drab and varies from thin bedded to blocky. There is a tendency for local structure to be present in some outcrops. This structure is shown in the calcareous lenses and does not reflect in the beds above or below them. This structure is possibly penecontemporaneous and might be the result of flowage on the sea floor during Johnson time. No fossils were observed in the Johnson shale. The thickness of this formation is about 25 feet.

This shale is easily recognized by the color, many limestone beds, and stratigraphic position above the Long Creek limestone (For detailed descriptions see measured sections 14 and 15).

Facies Changes in the Formation. Because outcrops of the Johnson are not numerous in Riley County, no comparative bases exist for stating facies changes.

Red Eagle Limestone

Naming of the Formation. The Red Eagle limestone (Table I) was named by Heald (1916 p. 24) after its type locality in the vicinity of Red Eagle School southwest of Foraker, Okla.

Miser (1926) indicated that the Cushing limestone is the same unit now called the Red Eagle limestone. Condra (1935, p. 8) defined the Red Eagle limestone as a formation underlying the Roca shale and overlying the Johnson shale.

The Red Eagle limestone is composed of three members. They are, in descending order, Howe limestone, Bennett shale, and Glenrock limestone.

Glenrock Limestone Member

Naming of the Member. The Glenrock limestone (Table I) was named by Condra (1927) on the basis of an outcrop high on a valley wall northwest of Glenrock, Nemaha County, Nebr.

Condra (1935, p. 9) defined the Red Eagle limestone with the Howe limestone member as the basal unit of the same formation, the classification that is followed in this report. The Howe limestone underlies the Bennett shale member and overlies the Johnson shale.

Areal Distribution. Most of the exposures of the Glenrock limestone are found in the vicinity of Manhattan (Plate I). Its area of outcrop extends from a short distance north of Manhattan to about 4 miles south of that city. This limestone crops out

south of the Kansas River in the eastern part of the county and on both sides of the valley at Deep Creek in T. 11 S., R. 8 E. The best exposures were observed in a road cut along the east side of Bluemont Hill in the [illegible] sec. 7, T. 10 S., R. 8 E., and in a railroad cut in [illegible] sec. 24, T. 10 S., R. 7 E.

Description of the Member. The Glenrock limestone is hard, massive, gray-brown and usually weathers tan. Fusulinids are abundant in all exposures of the Glenrock and other fossils noted in the field are: Arhoncella sp., Pseudobasus sp., Bellerophon sp., and numerous fossil fragments.

The Glenrock is more resistant to weathering than the other members of the Red Eagle and is therefore the bench former of the formation. The thickness of the Glenrock limestone is consistently 1.5 feet.

This limestone is easily recognized by its thickness, abundance of fusulinids, and stratigraphic position (For detailed descriptions see measured sections 14 and 15).

Facies Changes in the Member. No facies changes were observed in the Glenrock in Riley County.

Bennett Shale Member

Naming of the Member. The Bennett shale (Table I) was named by Condra (1927, pp. 84, 86, 89, 198). The type locality is along the Little Nemaha River and its branches south of Bennett, Lancaster County, Nebr. Condra (1935, p. 8) included

the Bennett shale as the middle member of the Red Eagle limestone. The Bennett shale thus lies between the Glenrock and Howe limestone members.

Areal Distribution. Outcrops of the Bennett shale almost invariably are associated with those of the Glenrock limestone (Plate I).

Description of the Member. The Bennett is a dark-gray to black, fissile to thin-bedded, clay shale. It is usually carbonaceous, slightly silty, and calcareous. Fossils found in this unit are: Composita ovata, Marginifera lasiricula, Juresania mormoni, Linoproductus cora, Dictyoclostus americanus, Polypora sp., Pleurophorus albequus, Amphicoelia planoconvexa, Aviculopecten occidentalis, Bellerella tetrahedra, Derbyia crassa, Orbiculoidea missouriensis. The thickness of the Bennett shale is almost constant at 5 feet.

The Bennett shale is easily identified by its dark, fossiliferous shale and its position above the easily identified Glenrock limestone.

Facies Changes in the Member. No important facies changes were observed in the limited exposures of the Bennett shale in Riley County.

Howe Limestone Member

Naming of the Member. The Howe limestone (Table I) was named by Condra (1927, pp. 64, 66, 68). The type locality is south of Howe, Nebr. Condra (1931, p. 9) designated the Howe

limestone as the top member of the Red Eagle limestone formation. The Rose limestone underlies the Roca shale and overlies the Bennett shale.

Areal Distribution. Outcrops of the Rose limestone almost invariably are associated with those of the Glenrock limestone (Plate I).

Description of the Member. The Rose limestone is tan, massive, soft and weathers rotten and porous. It is heavily limonite stained and, in most exposures, it usually contains some maroon stains derived from the overlying shales. Ostracods are very abundant in some zones of this limestone. Keo pirifera sp., and Aviculopinna peracuta are the macrofossils noted in the field. The average thickness of this limestone is about 4 feet.

This limestone is recognized by its weathering characteristics, color, presence of ostracods and stratigraphic position below the Roca shale (for detailed descriptions see measured sections 15 and 16).

Facies Changes in the Member. The only local facies change observed in the Rose limestone is a slight thickening toward the south.

Roca Shale

Naming of the Formation. The Roca shale (Table I) was named by Condra (1927, pp. 84, 86, 88). The type locality is at Roca, Lancaster County, Nebr.

Condra (1935, p. 9) later separated the Roca shale from the Neva limestone with which it previously had been grouped. The Roca shale overlies the Red Eagle limestone and underlies the Burr limestone member of the Grenola limestone.

Areal Distribution. Outcrops of the Roca shale are most numerous in the vicinity of the Manhatten, Kans. (Plate I). The outcrop area extends north as far as Rocky Ford, west to Stag Hill, east and south of the Kansas River, and along both sides of the valley at Deep Creek in T. 11 S., R. 9 E. Good exposures of this shale were at the top of the road cut in the SE¼ SE¼ NE¼ sec. 7, T. 10 S., R. 8 E. and at the top of the railroad cut in the NW¼ NW¼ NW¼ sec. 24, T. 10 S., R. 7 E.

Description of the Formation. The Roca shale is a veri-colored shale with a thin layer of limestone in the upper part and, in some places, a very thin limestone lens in the lower part. Maroon and tan shales occur locally but green and gray shales predominate in the formation. The only fossils found in the Roca shale are crinoid columnals in the upper limestone lens. The thickness of this unit is about 24 feet.

The Roca shale is the lowest, stratigraphically, of the veri-colored Permian shales. This shale is easily identified in the field by its veri-color and its position beneath the easily recognized Grenola limestone (For detailed descriptions see measured sections 15 and 16).

Facies Changes in the Formation. Two thin limestone lenses are present in the northern part of the outcrop area but were not found in the southern exposures of the Roca.

Grenola Limestone

The Grenola limestone (Table I) was named by Condra and Busby (1933) from outcrops in ravines and creeks north and south of Highway 160, 4 to 5 miles west of Grenola, Elk County, Kans.

Condra (1935, p. 9) divided the Grenola formation into the following members, in descending order: Nava limestone, Salem Point shale, Burr limestone, Legion shale, and Sallyards limestone. Moore (1936, p. 50) revised this classification by discarding the terms Legion shale and Sallyards limestones; this revision of the Grenola limestone is followed here.

Burr Limestone Member

Naming of the Member. The Burr limestone (Table I) was named as a formation by Condra and Busby (1933). The type locality is the bluffs and ravines west of the south fork on Little Kansas River at a point ½ mile west of a north-south road and 2½ miles northwest of Burr, Otoe County, Nebr. Later, Condra (1935, p. 8) reclassified the Burr limestone as a member of the Roca shale but Moore (1936, p. 50) placed it in the Grenola formation. Moore's assignment of the Burr is generally accepted today. The Burr limestone underlies the Salem Point shale and overlies the Roca shale.

Areal Distribution. Most of the Riley County exposures of the Burr limestone are restricted to the vicinity of Manhattan (Plate I). Some outcrops of the shale, however, were observed

in the area east and south of the Kansas River. The Burr limestone crops out as far as 4 to 5 miles north of Manhattan. Other exposures were observed along Deep Creek in T. 10 S., R. 6 E., and road cuts into this unit are exhibited in NE¼ NE¼ NE¼ sec. 7, T. 10 S., R. 8 E.

Description of the Member. The Burr limestone is a thick limestone interrupted by shale partings. Some of the beds of limestone are hard, dense, massive, and others are soft and porous. The limestone ledges are usually tan-gray and weather tan. The shale partings are clayey, usually noncalcareous, gray, and thin-bedded. The following fossils were found in the limestone layers: echinoid spines, Dictyoctenium granulifera, crinoid columnals, Aviculopecten occidentalis, Aviculopinna peracuta, Pleuroptorus albequus, Chaetetes sp., and microfossils. The total thickness of the Burr limestone is about 8 feet.

The Burr limestone is easily recognized by its stratigraphic position below the Neva limestone (For detailed descriptions see measured sections 15, 16, 17, 19, and 22).

Facies Changes in the Member. The Burr limestone, in the vicinity of Manhattan and southwest along Highway U.S. 40, consists of three beds of limestone and two black fissile shale partings. Southward, in sec. 7, T. 11 S., R. 8 E. an additional thin calcareous shale appears in the top limestone ledge.

Salem Point Shale Member

Naming of the Member. The Salem Point shale (Table I) was

named by Condra and Bushy (1923) from exposures in road cuts near Salem Point, 1½ miles northwest of Salem, Richardson County, Nebr. Condra, in 1935, placed the Salem Point shale member in the Brenola limestone. The Salem Point shale overlies the Burr limestone and underlies the Neva limestone.

Areal Distribution. Outcrops of the Salem Point shale almost invariably are associated with those of the Neva limestone (Plate I).

Description of the Member. The Salem Point is a thin-bedded, usually silty and calcareous shale. Numerous calcareous plates appear on weathered surfaces, a feature that can be used in identifying this shale. A calcareous lens is present locally. The color of the shale varies from tan to grey-green. There were no fossils observed in the Salem Point shale. The average thickness of this unit is about 8 feet.

The Salem Point shale is easily recognized in the field by the abundance of small calcareous plates on the weathered surface and by its position below the easily recognized Neva limestone (for detailed descriptions see measured sections 18, 19, and 22).

Facies Changes in the Member. The only facies change noted in this shale were minor variations in thicknesses. There is an apparent tendency of the Salem Point to thicken toward the south.

Neva Limestone Member

Naming of the Member. The Neva limestone (Table I) was named by Prosser (1902, p. 103). The type locality is in the valley of the Cottonwood River approximately 4 miles west of Strong City, Chase County, Kans. This limestone was named after Neva railroad station which at one time existed at the above location. A good exposure of the Neva can be seen in the SW¼ sec. 11, T. 19 S., R. 7 E.

Reede (1908, p. 130) first described the Neva limestone, and Condra and Busby (1933, p. 39) extended this unit into Nebraska and defined it as the top member of the Grenola formation. Moore (1936, p. 80) revised the classification of the Grenola limestone into the Neva limestone (restricted), Salem Point shale, and Burr limestone. Moore listed the Neva limestone as underlying the Eskridge shale and overlying the Roca shale. Foss (1937) included in the Neva limestone, a shale and limestone which lie above the massive bed described as the Neva at the type locality. It underlies the Eskridge shale and overlies the Salem Point shale.

Areal Distribution. The Neva limestone crops out in the vicinity of Manhattan and extend south nearly to the county line (Plate I). The limestone dips beneath the present land surface about 6 miles north of Manhattan and at a point about 2½ miles west of Manhattan. Prominent benches of the Neva limestone are especially conspicuous in the area south of Manhattan. Good exposures were observed in a road cut in the SW¼

NE¼ NE¼ sec. 26, T. 10 S., R. 7 E., along a bench light on E-
Hill in the NE¼ NW¼ sec. 20, T. 10 S., R. 8 E., and in a road
cut in the NW¼ SW¼ sec. 22, T. 10 S., R. 8 E.

Description of the Member. The Neva limestone is usually composed of thick limestones with a shale bed near the base and, in some exposures, other thin shales may occur also in the middle and upper parts of this member. The limestone layers are hard in the upper part of this unit but become soft in the lower part and are usually gray. The shales vary from gray to black.

Echinoid spines are abundant in some zones and other fossils commonly found in this member are: crinoid columnals, fusulinids, Chonetes granuliferus, Marginifera sp., Amboroelia expansa, Polypora sp., Composita ovata, and other fossil fragments. Lingula carbonaria and Orbiculoidea missouriensis are present only in the shales. The average thickness of the Neva limestone is about 16 feet. The top limestone bed forms the prominent bench which is characteristic of outcrops of the Neva. This member is identified in the field by its weathered light-gray limestone plates and blocks which, when broken, discloses numerous fossil fragments and echinoid spines. It is further recognized by its stratigraphic position beneath the easily identified Cottonwood limestone (For detailed description see measured sections 17, 18, 19, 20, and 21).

Facies Changes in the Member. The Neva limestone becomes more massive in the eastern part of the county and lacks the numerous shale partings which are distinctive of the unit in

the western outcrop area. This limestone tends to thin to the south.

Fakridge Shale

Naming of the Formation. The Fakridge shale (Table I) was named by Prosser (1902, p. 709) from outcrops near Fakridge, Wabaunsee County, Kans. Beede (1902, p. 101) described the Fakridge shale as overlying the Neva limestone and underlying the Cottonwood limestone.

Areal Distribution. The Fakridge shale is exposed beneath the Cottonwood limestone in the vicinity of Manhattan (Plate I). Numerous outcrops of the Fakridge occur along Highway K-13 between Manhattan and Stockdale. Excellent exposures of this shale were studied in a road cut in SW¼ SW¼ sec. 10, T. 10 S., R. 9 E., along an old road west of Highway U.S. 40 in the SW¼ NW¼ sec. 20, T. 13 S., R. 7 E., south of the Kansas River in T. 11 S., R. 7 and 8 E., and along the east side of Deep Creek in T. 11 S., R. 8 E. The uppermost part of this shale is present in a ditch in the southeastern corner of the county.

Description of the Formation. The Fakridge shale is predominantly shale with a few limestone lenses. The shale beds vary from clays to silts which may be calcareous or noncalcareous. Maroon, purple, green and tan-gray zones constitute the lower three-fourths of the Fakridge but the upper part is usually tan or gray. The limestone lenses are hard, dense, massive, and somewhat argillaceous. Fossils usually are found

only in some of the limestone lenses. The common fossils are: Dictyoclostus occidentalis, Hyalina sp., Pseudomonotis hawni, ostracods, and occasional brachiopods, plants and insects. Fossils occurring in a shale zone of the Eskridge were observed in a road cut in the NW¼ NW¼ sec. 9, T. 11 S., R. 7 E. The average thickness of the Eskridge shale is about 35 feet.

This unit is best identified in the field by its variicolored shales, pelecypod bearing limestones, and its position beneath the readily recognized Cottonwood limestone (For detailed descriptions see measured sections 17, 18, 19, 20, and 22).

Facies Changes in the Formation. The Eskridge shale thickens toward the north and northwest and in the same direction, the limestone lenses become thicker and more numerous. The position of limestones is extremely variable. The shale beds are predominantly calcareous in the northern and western outcrop areas and are noticeably less calcareous in the southern outcrop area.

Beattie Limestone

The Beattie limestone (Table I) was named by Condra and Busby (1933, p. 13). The type locality is near Beattie, Marshall County, Kans. They subdivided the formation into the following members (in descending order): Merrill limestone, Florena shale, and Cottonwood limestone.

Cottonwood Limestone Member

Naming of the Member. The Cottonwood limestone (Table I) was named by Haworth and Kirk (1894, p. 113-114). The type locality is the valley of the Cottonwood River, Chase County, Kans. Prosser (1902, pp. 711, 712) was the first to describe the limestone adequately at its type locality. The limestone here classified as the Cottonwood appears in early reports as the Cottonwood stone, "Fusuline limestone," "Cottonwood Falls limestone," "Alma limestone," and the "Manhattan limestone."

The Cottonwood limestone overlies the Eskridge shale and underlies the Florens shale.

Areal Distribution. Outcrops of the Cottonwood limestone are especially prominent in the vicinity of Manhattan (Plate I). This limestone forms a continuous bench on both sides of the Kansas River, and extends almost as far south as the Geary County line and in at least one place, along McDowell Creek, into Geary County. Outcrops of this member extends along the Blue River to a point one mile north of Stockdale where it passes beneath the present land surface. Outcrops were observed in the southeastern part of the county. This unit is exhibited on both sides of Wildcat Creek to a point 5 miles west of Manhattan.

Description of the Member. The Cottonwood limestone is a single massive layer with a thin argillaceous zone in the basal part. In most outcrops this limestone weathers into three more or less distinct ledges. Two to three thin lenses of chert

nodules are usually present in the massive part of the limestone. The limestone is gray and weathers tan-gray. Fusulinids are abundant in this member and solution channels occasionally are present. Other fossils noted in the Cottonwood are: Dictyoclostus americanus, colonial corals, crinoid columnals, Derbyia sp., Composita sp., Straparolus sp., and Pelmora sp. The average thickness of this limestone is about 5.5 feet.

The massive bed of the Cottonwood limestone forms the most prominent hillside bench in the vicinity of Manhattan. A heavy growth of bushes at the base of this limestone usually marks its position on the hillside. The growth of this line of bush, at this contact, is the result of movement of subsurface water along fracture planes.

The Cottonwood is easily identified in the field by its thickness, massiveness, abundance of fusulinids, chert nodules, and "rustline" outcrop (for detailed descriptions see measured sections 17, 18, 19, 20, 21, and 22).

Facies Changes in the Member. No significant facies changes were noted in the Cottonwood limestone in Riley County; this member is perhaps the most constant lithologically and paleontologically of all the sedimentary units cropping out locally.

Florena Shale Member

Naming of the Member. The Florena shale (Table I) was named by Prosser (1902, p. 713). The type locality is in quarries near Florena, Marshall County, Kans. The United States

Geological Survey classified the Florena shale as the lowest member of the Garrison formation but Moore (1935, p. 30) discarded the name Garrison and substituted Seattle, a practice now widely followed. The Florena shale underlies the Morrill limestone and overlies the Cottonwood limestone.

Areal Distribution. The Florena shale almost always is exposed above outcrops of the Cottonwood limestone (Plate I). One of the best fossil-collecting localities in this shale is an old quarry just north of Kansas State College in the NE¼ SE¼ NE¼ sec. 7, T. 10 S., R. [illegible] E.

Description of the formation. The Florena is a thin-bedded to blocky clay shale predominantly calcareous, and containing numerous calcareous plates and nodules. The fresh shale varies from tan to gray to olive drab but it weathers tan. In some exposures, fossils are abundant in the lower 3 or 4 feet only. Chonetes granulifera is exceptionally abundant in the shale. Other fossils that may be abundant or numerous are: Derbyia crassa, D. wabaunseensis, Composita ovata, C. subtilita, Fusulinids, Straparolus sp., Dictyoclostus americanus, D. portlockianus, Meekella striatocostata, Polypora sp., Fenestella sp., crinoid columnals and calyx plates, Allorisma terminale, Rhombopora sp., Stenopora sp., Lissochonetes geinitzianus, Cremia modesta, trilobites, and microfossils. The average thickness of the Florena shale is about 7 feet.

This shale can best be identified in the field by the abundance of Chonetes granulifera, plus other fossils and its position above the easily recognized Cottonwood limestone (For

detailed descriptions see measured sections 18, 19, 20, 21, and 22).

Facies Changes in the Member. The Florena shale, in the northern outcrop area, becomes a dark gray to olive drab. This shale is predominantely clayey in the southeastern outcrop area.

Morrill Limestone Member

Naming of the Member. The Morrill limestone (Table I) was named by Condra (1927, pp. 234, 235, 237). The type locality is west and ½ mile north of Morrill, Kans. Condra and Upp (1931, p. 18) redesignated the type locality as an outcrop about ½ mile north of the original type locality and east of a north-south road in the northwest corner of sec. 27 and southwest corner of sec. 22. The Morrill limestone overlies the Florena shale and underlies the Stearns shale.

Areal Distribution. The outcrop area of the Morrill limestone is almost the same as that of the Cottonwood limestone (Plate I). Outcrops of the Morrill, however, are not so clearly exposed and are fewer in number. This limestone is exhibited in a road cut in the SW¼ NE¼ NW¼ sec. 34, T. 10 S., R. 9 E. and another good exposure of this limestone was observed in a road cut in the NW¼ NW¼ sec. 33, T. 9 S., R. 7 E.

Description of the Member. The Morrill limestone varies greatly in hardness, is slightly argillaceous, and is tan-gray to gray-orange and weathers tan. The limestone is massive in a fresh exposure but weathers quite porous and irregular with

the top part developing an algal like appearance. Three well-defined ledges are usually present in most exposures of the Morrill. There were no fossils observed in this member in Riley County. The average thickness of this limestone is about 2.5 feet.

The Morrill limestone can be identified in the field by its stratigraphic position above the easily recognized Cottonwood limestone (For detailed descriptions see measured sections 19, 20, 21, and 22).

Facies Changes in the Member. The only facies change noted in the Morrill limestone in Riley County is a tendency to thicken slightly toward the south.

Eskridge Shale

Naming of the Formation. The Eskridge shale (Table I) was named by Condra (1927, p. 230, 233, 234, 235, 237). The type locality is south of Eskridge School, northeast of Humboldt, Nebr. Condra and Upp (1931, p. 10) redesignated the type locality as along a north-south road 6 miles south and ½ mile east of Humboldt, Nebr. The Eskridge shale overlies the Morrill limestone and underlies the Wise limestone.

Areal Distribution. The Eskridge shale outcrop area in Riley County extends 9 miles north of Manhattan, 4 miles toward the west, and south along both sides of the Kansas River to the Geary County line (Plate I). Good exposures of the Eskridge were found in road cuts in the [illegible] sec. 34, T. 10 S., R. 8 E.,

in the NW¼ SW¼ sec. 33, T. [illegible], R. 7 E., and in the SW¼ NW¼ sec. 9, T. 11 S., R. 7 E.

Description of the formation. The Stearns is mostly a silty, calcareous, gray to olive drab shale that weathers light-gray to tan. It is thin-bedded to blocky, and thin calcareous lenses and plates are usually present near the base. Limonite stains are frequently present on the bedding planes. No fossils were observed in the Stearns shale in Riley County. The average thickness of this shale is about 14 feet.

The Stearns shale is best recognized in the field by its stratigraphic position below the Fise limestone (for more detailed descriptions see measured sections 19, 20, 21, and 22).

Facies Changes in the formation. The lower half of the Stearns shale, in the southern part of the outcrop area, consists of dark gray to olive drab shales but changes to zones of black fissile and maroon beds in the northern part of the outcrop area.

Bader Limestone

The Bader limestone (Table I) was named by Condra (1930, pp. 4, 7) from outcrops near Bader in Clase County, Kans.

The Bader limestone consists of the Middleburg limestone member in the upper part, the Hooser shale member in the middle part, and the Fise limestone member in the lower part. The total thickness of this formation is about 16 feet.

Ries Limestone Member

Naming of the Member. The Ries limestone (Table I) was named by Condra (1927, pp. [illegible], 233, 234, 235, 237). The type locality is located in the [illegible] sec. 3, T. 1 S., R. 13 E. on the Ries farm 5 miles south of Humboldt, Nebr. The Ries limestone underlies the Hooser shale and overlies the Stearns shale.

Areal Distribution. The outcrop area of this limestone extends 9 miles northwest and 3 miles west of Manhattan and south to the Geary County line (Plate I). Good exposures of this limestone were studied in road cuts in the [illegible] sec. 34, T. 10 S., R. 9 E., in the [illegible] sec. 33, T. 9 S., R. 7 E., and in the [illegible] sec. 9, T. 11 S., R. 7 E.

Description of the Member. The Ries limestone usually consists of two limestones separated by a shale. The limestones are hard, massive but weathering blocky or porous, and are gray to tan-gray in color. The intermediate shale is thin-bedded, clayey to silty, calcareous, and usually tan or tan-gray. Fossils found in the limestone layers are: Aviculopecten occidentalis, Pseudomonotis hawni, Myalina sp., Nuculla strictocostata, Derbyia crassa, Composita sp., echinoid spines, and crinoid columnals. The average thickness of this limestone is about 5 feet. The Ries limestone forms the first prominent hillside bench above the Cottonwood limestone. This bench is usually covered with weathered, porous, square blocks, which are one to two feet in diameter.

This limestone can easily be identified in the field by

these weathered blocks, and its position above the readily identified Cottonwood limestone (For detailed descriptions see measured sections 19, 20, 21, 22, and 23).

Facies Changes in the Member. The Ellis limestone, in the northern outcrop area, is composed of three limestones separated by two beds of dark shale but in the southern part of the outcrop area there are only two limestone beds separated by a shale and there are four thin limestones and three shales comprising the Ellis in the eastern outcrop area. This unit thickens southward because of thickening of the shale parting.

Hooser Shale Member

Naming of the Member. The Hooser shale (Table I) was named by Condra and Upp (1931, pp. 20, 21). The type locality is a highway cut and ravine just east of Hooser, Cowley County, Kans. The Hooser shale underlies the Middleburg limestone and overlies the Ellis limestone.

Areal Distribution. The Hooser limestone almost invariably are associated with those of the Ellis limestone (Plate I). Good exposures of this shale were observed in road cuts in the SE¼ SW¼ NE¼ sec. 34, T. 10 S., R. 9 E., and in the NE¼ NE¼ sec. 28, T. 10 S., R. 9 E., as well as in a bank of a stream in the NE¼ SE¼ sec. 36, T. 11 S., R. 8 E.

Description of the Member. The Hooser consists of varicolored shale (maroon, green, gray and olive drab) zones composed of silt, clay, and are predominantly calcareous and blocky.

There were no fossils found in this member. The average thickness of the looser shale is about 8 feet.

This shale can best be identified in the field by its stratigraphic position between the Hiss and Middleburg limestones (For detailed descriptions see measured sections 20, 21, 22, and 23).

Facies Changes in the Member. The looser shale thickens slightly toward the southeast.

Middleburg Limestone Member

Naming of the Member. The Middleburg limestone (Table I) was named by Condra and Upp (1931, pp. 20, 28). The type locality is along Daily Creek, 1½ miles south of Middleburg School in the ½ sec. 36, T. 1 N., R. 13 E., in the southwestern Richardson County, Nebr.

Areal Distribution. The Middleburg limestone is almost invariably associated with outcrops of the Hiss limestone (Plate I). The Middleburg is well exposed in road cuts in the SW¼ SE¼ NW¼ sec. 34, T. 10 N., R. 9 E. and in the NW¼ NE¼ SE¼ sec. 7, T. 11 N., R. 8 E.

Description of the Member. The Middleburg limestone consists of two limestones which are usually separated by a shale. The limestones are massive, hard, dense, and somewhat crystalline. They are grey to olive drab and usually weathers light gray but in most exposures the weathered surface is covered with maroon stains. The intervening shale bed is silty, calcareous,

grey to black, and thin-bedded. The basal limestone layer contains the following fossils: Aviculopecten occidentalis, Polypora sp., Pseudomontis hawni, Pleurophorus sp., and crinoid columnals. Algae occur locally in the upper limestone. The average thickness of this limestone is about 4 feet.

The Middleburg seldom crops out conspicuously but occasionally a small bench can be identified between the Crouse and Hiss limestones.

The Middleburg can best be identified in the field by two limestones with a dark shale parting and by its presence above the Hiss limestone (For detailed descriptions see measured sections 21, 22, and 23).

Facies Changes in the Member. There were no important facies changes noted in the Middleburg limestone in Riley County.

Hasly Creek Shale

Naming of the Formation. The Hasly Creek shale (Table I) was named by Condra (1927, pp. 233-237). The type locality is on Hasly Creek, in the NE¼ sec. 35, T. 1 N., R. 13 E., 10 miles south and 1½ miles east of Humboldt, Richardson County, Nebr.

Areal Distribution. The Hasly Creek shale is almost invariably associated with the Crouse limestone (Plate I). The Hasly Creek shale is exposed in a road cut in the SW¼ SE¼ NE¼ sec. 34, T. 10 S., R. 9 E. Another good exposure can be observed in an old road cut in the SW¼ NW¼ NW¼ sec. 7, T. 11 S., R. 8 E. A third exposure of this shale is exhibited in a road cut

in the [illegible] sec. 23, T. 10 N., R. 7 E.

Description of the Formation. The Early Creek shale is variable in color. Drab, greenish-gray, and maroon predominate. The upper part is gray-green to gray and lower part is mostly maroon. This shale is composed predominantly of calcareous silt and is thin-bedded to blocky. A thick, hard, massive limestone occurs in the upper part of the Early Creek. There were no fossils observed in this formation. The average thickness of this shale is about 20 feet.

This shale can be identified in the field by its position beneath the easily recognized Crouse limestone (For detailed descriptions see measured sections 21, 22, 23, and 31).

Facies Changes in the Formation. The limestone here varies in its vertical position in the Early Creek shale. Although the limestone thickens toward the north, the shale thickens toward the southwest.

Crouse Limestone

Naming of the Formation. The Crouse limestone (Table I) was named by Heald (1916, pp. 21, 28). The type locality is Crouse Hill in the Foraker quadrangle, Osage County, Okla. Condra (1935, pp. 4, 6) included the Crouse limestone as the basal member of the Pigeon formation but later abandoned the Pigeon as a formational unit.

Areal Distribution. The Crouse limestone crops out south and west of Manhattan (Plate I). Crouse benches at a point a

short distance north of Hodgdale, and are exposed, in the vicinity of Cleburne, in a stream bank in the NE¼ NW¼ sec. 17, T. 6 S., R. 7 E., and at the base of a road cut just north of that city. This limestone is well exposed in road cuts in the NW¼ SE¼ NE¼ sec. 7, T. 11 S., R. 6 W. and in the NE¼ NE¼ sec. 29, T. 10 S., R. 8 E.

Description of the Formation. The upper part of the Crouse limestone consists of thin-bedded limestones separated by numerous thin shale partings whereas the lower part is massive. The limestones are hard, dense, weather blocky to platy, and are gray and brown and weather tan to gray. There are a few fossil fragments present in this limestone. The average thickness of the Crouse limestone is about 7 feet.

The Crouse limestone forms a prominent bench above the Wise limestone. Thin limestone plates are abundant on the weathered surface and usually cover the more massive beds. Two hillside benches are formed by this limestone in the southeastern part of the county. A platy limestone bench lies a few feet above a second small bench covered by blocks of weathered limestone.

This limestone can be easily identified in the field by the numerous limestone plates present in the weathered surface (For detailed descriptions see measured sections 22, 23, 24, and 31).

Facies Changes in the Formation. There were no facies changes observed in the Crouse limestone in this county.

Blue Rapids Shale

Naming of the Formation. The Blue Rapids shale (Table I) was named by Condra and Reed (1931, p. 32). The type locality is in a road cut along [illegible] U.S. 77 about 1½ miles north of Blue Rapids, Kans. Condra (1932, pp. 7, 8) designated the Blue Rapids shale as the middle member of the Bigelow limestone. He later discarded the Bigelow and redefined the Blue Rapids shale as a formation.

Areal Distribution. A good exposure of the Blue Rapids shale was observed in a road cut in the SW¼ NW¼ sec. 29, T. 8 S., R. 7 E. This shale is exhibited in a road and railroad cut in the NE¼ SW¼ sec. 8, T. 9 S., R. 7 E., and a very good section of this shale is exposed in a road cut in the SW¼ NW¼ sec. 33, T. 10 S., R. 6 E.

Description of the Formation. The Blue Rapids shale is predominantly gray to tan but contains maroon and green zones in the middle part. This unit is thin-bedded to blocky silt and clay shale. Calcium carbonate nodules and thin argillaceous limestone lenses occur in the upper part of this shale in the northern outcrop area. There were no fossils observed in the Blue Rapids shale. The average thickness of this formation is about 20 feet.

The Blue Rapids shale is easily identified in the field by its stratigraphic position between the Crouse and Funston limestones both of which usually crop out conspicuously (For detailed descriptions see measured sections 23, 24, 25, and

21).

Facies Changes in the Formation. A thin limestone lens is present in the northern outcrop area. The thickness of the Blue Rapids shale is nearly constant in Riley County. Tan shales predominate in the northern part of the county whereas gray-green, gray and maroon shales are more abundant in the center and southern parts of the outcrop area.

Funston Limestone

Naming of the Formation. The Funston limestone (Table I) was named by Condra and Upp (1931, p. 58). The type locality is at Camp Funston, Riley County, Kans. Condra (1935, pp. 4, 6) designated the Funston limestone as the youngest member of the Pillow formation. He later discarded this classification and redefined the Funston limestone as a formation.

Areal Distribution. The Funston limestone crops out in the eastern half of the county (Plate I). Exposures of this limestone were observed along the Blue River as far north as Cleburne and over the area lying immediately south and west of Manhattan. A good exposure of this limestone was observed in a road cut in the [illegible] sec. 33, T. 12 S., R. 8 E., and another good section is exhibited in a road cut in the [illegible] sec. 29, T. 8 S., R. 7 E.

Description of the Formation. The Funston limestone consists of two limestone beds with a shale parting in the lower or middle part. The limestones are soft, sandy-appearing, massive

and weather blocky to platy and porous. They are tan to grey-brown and weather tan but a veneer of maroon stain usually conceals the surface of the upper limestone. Calcareous nodules are sometimes present in this unit in the southern outcrop area and chert nodules were noted in the lower limestone in the NE¼ NW¼ sec. 23, T. 9 N., R. 7 E. No fossils were observed in this formation. The average thickness of the Funston limestone is about 8 feet. The Funston limestone forms a hillside bench just below the prominent terrace formed by the Three Mile limestone bench.

This limestone can easily be identified in the field by its position below the Three Mile limestone (For detailed description see measured sections 23, 24, 25, 26, and 31).

Facies Changes in the Formation. The Funston limestone thickens and becomes very massive toward the southwest. One bed is 6 feet thick and forms a very prominent hillside bench as can be observed in the SW¼ NW¼ sec. 18, T. 11 N., R. 7 E. The Funston limestone thins in the southeastern and northern outcrop areas. In the latter, the Funston is composed of three limestones with two conspicuous shale partings.

Speiser Shale

Naming of the Formation. The Speiser shale (Table I) was named by Condra (1927, pp. 232, 234). The type locality is in the E½ sec. 35, T. 1 N., R. 13 E., Speiser Township, Richardson County, Nebr.

Condra and Upp (1931, p. 23) divided the Speiser shale into the following: Speiser shale (restricted), Funston limestone, and Blue Rapids shale members. Condra later discarded this classification and designated each member as a formation.

Areal Distribution. Outcrops of the Speiser shale almost invariably are associated with those of the Threemile limestone (Plate I). Good exposures of the Speiser shale were observed in road cuts in the SW¼ NW¼ sec. 33, T. 10 S., R. 6 E., in NE¼ NW¼ sec. 21, T. 11 S., R. 6 E., in the SE¼ NE¼ sec. 20, T. 8 S., R. 7 E., in the SW¼ NE¼ sec. 6, T. 6 S., R. 7 E., and in the NW NE¼ sec. 15, T. 6 S., R. 7 E. The Speiser shale was studied in Kitten Creek east of Keats and Winkler along Fancy Creek.

Description of the Formation. The Speiser shale is tan-gray, gray, green, purple and maroon in color. There is a persistent limestone one foot thick about 3 feet from the top and in most exposures there is a second thin limestone just below the base of the Threemile limestone, which are thin-bedded to blocky, from silty to clayey and most of the beds are calcareous. The layers of limestone are hard, massive, and gray to gray-orange. The following fossils were found in the top part of the Speiser: crinoid columnals, echinoid spines, Juresania nebrascensis, Derbyia crassa, Cleonetes granulifera, Dictyoclostus americanus, and trilobites. The average thickness of the Speiser shale is about 15 feet.

This shale can best be identified in the field by its varicolors, fossiliferous zone, a thin persistent limestone in the

upper part, and by its position below the readily identified Threemile limestone (For detailed descriptions see measured sections 23, 24, 25, 26, 27, and 31).

Facies Changes in the Formation. The Speiser shale thickens gradually toward the north. The maximum difference being about 4 feet throughout the north-south extent of the county. In the southern part of its outcrop area a second limestone occurs below the persistent limestone of this shale. The top shale bed becomes dark grey to olive drab in the northern outcrop area.

The Chase group was first called a formation by Prosser (1895, pp. 771-776) and included in it all units from the Winfield limestone down to the base of the Wreford limestone. The Chase formation was later given the rank of group. Moore (1936, p. 19) placed the top of the Chase group so as to include the Luta limestone. Moore, Frye, and Jewett (1944, p. 180) define the Chase group to include the following formations (descending order): Nolan limestone, Odell shale, Winfield limestone, Doyle shale, Barneston limestone, Matfield shale, and the Wreford limestone.

Wreford Limestone

The Wreford limestone (Table I) was named by Ley (1903, p. 104). The type locality is near Wreford, Geary County, Kans. Prosser (1902, p. 713) defined the Wreford limestone as overlying

tle Garrison formation and underlying the Matfield shale.

The Wreford limestone is composed of the Schroyer limestone member in the upper part, the Havensville shale member in the middle, and the Threemile limestone member in the basal part.

Threemile Limestone Member

Naming of the Member. The Threemile limestone (Table I) was named by Moore (1936, p. 12) and designated as the basal member of the Wreford limestone. The type locality is along Threemile Creek on the Fort Riley Military Reservation.

Gay (1903) is usually given credit for the name Threemile through his suggestion of it as a possible name for this stratum. Condra and Upp (1931, p. 31) recommended that the lowest member of the Wreford limestone be named the Fourmile limestone. This name was rejected, however, since it previously had been applied to a sandstone in the Pennsylvanian system.

Areal Distribution. The Threemile limestone crops out in many places in the eastern half of Riley County (Plate I). It is exposed extensively along the Blue River from Manhattan to within a few miles of the Marshall County line and south of Manhattan as far west as Keats. The Threemile is exposed in the vicinity of Winkler on Fancy and Otter Creeks. A good exposure was studied in a road cut in the SE¼ NW¼ sec. 33, T. 10 S., R. 8 E. Other excellent outcrops of this limestone are exhibited in Bitter Creek east of Keats and in a road cut in

the SW¼ NE¼ sec. 6, T. [illegible], R. 7 E.

Description of the Formation. The Threemile limestone usually consists of a thick nonflinty bed in the upper part and flinty beds in the lower part, although in some exposures, chert nodules and lenses are present throughout the full thickness of the limestone. A thin shale parting is present in the lower part. Shale partings were observed in the upper part of one exposure of this limestone. The limestones are light gray and weather light gray to tan-gray and are massive but weather blocky. The shale parting near the base of the member is silty, calcareous, thin-bedded, and fossiliferous. The fossils present in the Threemile limestone are: echinoid spines, crinoid columnals, Allorisma terminale, Pleurophorus americanus, Aviculopinna peracuta, Aviculopecten occidentalis, Derbyia crassa, D. kansasensis, Composita ovata, Juresania nebrascensis, and Amboccelia sp. The average thickness of the Threemile limestone is about 7 feet.

The non-cherty upper part of the Threemile limestone is more resistant to weathering than the chert bearing beds and, therefore, forms a prominent bench on most of the hillsides in its area of outcrop.

This member is easily identified in the field by its cherty limestones, persistent fossiliferous shale near the base, by the light gray limestones which forms the hillside bench (For more detailed descriptions see measured sections 23, 24, 25, 26, 27, and 31).

Facies Changes in the Formation. The Threemile limestone

thickens toward the south. A shale zone at the top and two shale partings near the base were observed in the Threemile in the area north of Randolph. In this locality most of the chert is restricted to four well defined bands. The position and quantity of chert varies locally.

Havensville Shale Member

Naming of the Member. The Havensville shale (Table I) was named by Condra and Upp (1931, p. 32). The type locality is in a road cut on Highway U.S. 63 about 2 miles south of Havensville, Kans. The Havensville shale overlies the Threemile limestone and underlies the Schroyer limestone.

Areal Distribution. Outcrops of the Havensville shale almost invariably are associated with those of the Schroyer limestone (Plate I).

Description of the Member. The Havensville is composed predominantly of shale with limestone lenses present in the upper part. The shale is mostly clay but contains some silt. It is calcareous, thin-bedded and olive drab to dark gray. The calcareous zone near the top is massive and soft and varies in thickness throughout the county. The fossils found in this shale are: Ambocoelia sp., Aviculopinna peracuta, Allorisma terminale, Polypora sp., crinoid columnals, Myalina sp., Pleurophorus sp., Derbyia crassa, Aviculopecten occidentalis, and Juresenia nebrascensis. The average thickness of the Havensville shale is about 21 feet.

This shale is best identified in the field by its stratigraphic position between the Fort Scott and Nehawka limestones (For detailed descriptions see measured sections 23, 24, 25, 26, 27, and 31).

Facies Changes in the Member. In a stream cut in the [illegible] NE¼ sec. 10, T. 7 S., R. 6 E. there is a thick limestone bed near the middle of the Lawrenceville with two thin limestone lenses in the upper part and two thin limestone lenses near the base. Aviculopecten occidentalis and Myalina sp., are very abundant in the middle limestone layer. The shales and limestones at this location are dark gray in color. In the southern outcrop area, there are two thin limestone lenses in the upper part of this unit and four thin limestone lenses are present in the upper part and two lenses in the basal part in the vicinity of Manhattan. Only one limestone lens was observed in this shale in the vicinity of Stockdale. Near Winkler, the upper part of the Lawrenceville contains 5 to 6 feet of massive limestone. The total thickness of the Lawrenceville shale varies but little over the area of outcrop.

Nehawka Limestone Member

Naming of the Member. The Nehawka limestone (Table I) was named by Condra and Upp (1931, p. 33). The type locality is on the east side of the valley at the Big Blue River about 1½ miles below Nehawka, Marshall County, Kans. The Nehawka limestone overlies the Lawrenceville shale and underlies the

Lynore shale.

Areal Distribution. The outcrop areas of the Schroyer limestone are nearly the same as those of the Threemile limestone (Plate I). In most of the outcrop area, this limestone forms a bench higher, and back from that formed by the Threemile limestone. The Schroyer limestone was studied in road cuts in the NE¼ NW¼ sec. 21, T. 11 S., R. 8 E., and in the NW¼ SW¼ sec. 29, T. 8 S., R. 7 E., as well as in a stream bank in the SW¼ NW¼ sec. 15, T. 7 S., R. 6 E. Other exposures of this limestone are well displayed in the vicinity of Winkler and Cleburne.

Description of the Member. The Schroyer limestone is usually a massive limestone bed in which thin chert bands and occasional shale partings are intercalated. Chert nodules are usually scattered throughout most of the limestone beds. The limestones are hard, dense, and usually light grey. Fossils noted in this limestone are: crinoid columnals, Cladochonus granulifera, Fenestella sp., echinoid spines, Anomocoelia planoconvexa, Juresania nebrascensis, Dictyoclostus sp., Composita sp., and Allorisma sp. Ostracods are very abundant in the very top part of the Schroyer. The average thickness of this limestone is about 9 feet.

The upper, usually non-flinty, limestone bed forms a prominent hillside bench.

This limestone is readily identified in the field by its chert limestones, and by its position above the easily recognized Threemile limestone (For detailed descriptions see

measured sections 25, 26, 27, and 31).

Facies Changes in the Member. The Belroger, north of Stockdale, is a massive cherty limestone with only a single thin shale parting. Part of north of Stockdale, and toward the south as well, this shale bed increases markedly in its thickness. A shale parting is also present in the middle of the limestone in the northern area of outcrop. The position and quantity of chert beds and nodules vary locally. The thickness of the Belroger limestone is nearly constant in this county.

Matfield Shale

The Matfield shale (Table I) was named by Prosser (1902, p. 714). The type locality is in Matfield Township, Chase County, Kans. The Matfield shale is composed of the Blue Springs shale member in the upper part, the Kinney limestone member in the middle part, and the Wymore shale member in the lower part.

Wymore Shale Member

Naming of the Member. The Wymore shale (Table I) was named by Condra and Upp (1931, p. 37). The type locality is in ravines on the west side of a creek 2½ miles east of the south side of Wymore, Gage County, Nebr. The Wymore shale underlies the Kinney limestone and overlies the Threford limestone.

Areal Distribution. Outcrops of the Pymore shale almost invariably are associated with those of the Florence limestone (Plate I). Good exposures of the Pymore were observed in road cuts in the NE¼ NW¼ sec. 21, T. 11 S., R. 2 E., in the NW¼ SW¼ sec. 29, T. 9 S., R. 7 E., and in the NE¼ NE¼ sec. 32, T. 6 S., R. 7 E.

Description of the Member. The Pymore is a calcareous, clayey but somewhat silty, blocky to thin-bedded shale. Tan-gray, gray-green and maroon shales predominate in the lower part of the member and gray-green, olive drab, and sometimes maroon shales in the upper part. Two thin fossiliferous limestones are usually present in most exposures of the Pymore. The fossils found in the limestone beds are: Aviculopecten occidentalis, Chaetetes sp., and Orthotetes subquadrata. The average thickness of this member is about 45 feet.

This shale can easily be identified in the field by its stratigraphic position below the Florence limestone and above the Polroper limestone (For detailed description see measured sections 27, 28, 29, 30, and 31).

Facies Changes in the Member. The Pymore shale thins northward from the central part of the outcrop area. The fossiliferous limestone lenses are present in the middle of this shale in the southern and northern outcrop area and these limestones thin northward. Very fossiliferous shales occur above the limestone lenses in the southeastern outcrop area. The fossils found abundantly in these shales are: Derbyia crassa, Composita ovata, and Rhombopora sp. Less numerous are: Derbyia

wabaunseensis, D. deercreekensis, Juresania nebrascensis, echinoid spines, and crinoid columnals. Maroon shales are also present in the top part of this shale but they occur only in the southern outcrop area.

Kinney Limestone Member

Naming of the Member. The Kinney limestone (Table I) was named by Condra and Upp (1931, p. 37) from outcrops along the Burlington railroad cut just east of Kinney, Nebr. The Kinney limestone overlies the Wymore shale and underlies the Blue Springs shale.

Areal Distribution. Outcrops of the Kinney limestone almost invariably are associated with those of the Florence limestone (Plate I). See the Wymore shale member for the location of good exposures.

Description of the Member. The Kinney is a soft, massive, and slightly dolomitic limestone. The color is either light gray or tan with abundant black specks dispersed throughout the rock. Balls or nodules of clay occur locally and a line of chert nodules was found in one exposure of the Kinney. The fossils found in this limestone are: echinoid spines, crinoid columnals, Derbyia s ., and Allorisma terminale. Microfossils are abundant in the very top part of this unit. The average thickness of the Kinney limestone is about 2.5 feet in Riley County.

The Kinney limestone sometimes forms a small hillside

bench but its outcrop expression usually is a weak one.

This limestone can best be identified in the field by its soft, massive limestone and by its position below the Florence limestone (For detailed descriptions see measured sections 27, 28, 29, 30, and 31).

Facies Changes in the Member. The Kinney limestone thickens slightly toward the southwest and north. A thin shale parting in the basal part of this unit was noted in the northern outcrop area and microfossils were found only in the southeastern outcrops. Microfossils are present in the top part of the Kinney in nearly all exposures. Chert nodules were observed in the limestone in the NE¼ SW¼ sec. 7, T. 2 S., R. 3 W.

Blue Springs Shale Member

Naming of the Member. The Blue Springs shale (Table I) was named by Condra and Upp (1931, p. 38). The type locality is at the base of the bluffs along the Blue River, southeast of Blue Springs, Gage County, Nebr. The Blue Springs shale overlies the Kinney limestone and underlies the Florence limestone.

Areal Distribution. Outcrops of the Blue Springs shale almost invariably are associated with those of the Florence limestone (Plate I). Good exposures of the Blue Springs were observed in road cuts in the SW¼ NE¼ sec. 21, T. 11 S., R. 9 E., in the NE¼ SW¼ sec. 20, T. 8 S., R. 7 E., and just north of Cleburne.

Description of the Member. The Blue Springs shale is predominantly clayey and calcareous in most exposures. Its color varies from maroon and green at the base to gray, green and sometimes tan in the upper part. Lenses of hard, massive, tan-gray limestone commonly occur near the top of the member. There were no fossils observed in this shale. The average thickness of the Blue Springs is about 20 feet.

This shale is easily identified in the field by its stratigraphic position immediately below the Florence limestone (For detailed descriptions see measured sections 29, 30, 31, 31, and 32).

Facies Changes in the Member. The Blue Springs shale thickens toward the west. It is thin in the southern part of the county but thickens slightly toward Randolph and was more in the vicinity of Cleburne. A very thick outcrop is exposed just east of Ogden. Three limestones occur near the top of this shale in the southern outcrop area and one in the middle part but only two limestone beds are present in the northern area of outcrop. Calcareous lenses are present in the top part in the exposure east of Ogden. Maroon and more silty shales predominate in the northern outcrop area.

Parmeston Limestone

The Parmeston limestone (Table I) was named by Condra and Upp (1931, p. 41). The type locality is in the bluffs, west and southwest of Parmeston, Gage County, Nebr. The Parmeston

limestone consists of the Fort Riley limestone member in the upper part, the Oketo shale member in the middle part, and the Florence limestone member in the lower part.

Florence Limestone Member

Naming of the Member. The Florence limestone (Table I) was named by Prosser (1[illegible], pp. 7[illegible]1-7[illegible]6, 79[illegible]). The type locality is near Florence, Marion County, Kans. Prosser (1902) included the shaly limestone above and below the originally defined limestone bed as part of the Fort Riley limestone. He stated also that the Fort Riley rested on the Florence and included part of the main ledge of the Fort Riley main ledge in the Barneston. These conclusions led Prosser to abandon the name Florence limestone. Moore, in 1932, redefined the units and designated the Florence as the limestone overlying the Blue Springs shale and underlying the Oketo shale.

Areal Distribution. The Florence limestone crops out principally in a wide belt extending from Cloburne toward the southwest corner of the county (Plate I). Exposures in the southern part of the county are confined to the area along the county line as far east as Highway K-13. Because of an anticlinal fold, the Florence limestone reappears at the surface in the vicinity of Winkler. The Matfield shale crops out, in numerous exposures, beneath the prominent bench formed by the Florence. Excellent sections of the Florence limestone were studied in road cuts along Highway K-13 at the southern boundary

of the county, in the NW¼ SW¼ sec. 29, T. 8 S., R. 7 E., and just north of Cleburne. It is well exposed in a stream bank north of Winkler and along North Otter Creek.

Description of the Member. The Florence is composed of massive beds of limestone containing numerous bands and nodules of chert. A thin shale parting is usually present near the top of this member but, in an exposure west of Winkler, three shale partings occur. The limestone is hard, massive, and weathers blocky. It is usually light grey to grey and weathers light gray to tan-gray. The shale partings are tan-gray to gray and include thin calcareous lenses. Fossils are more abundant in the shales than in the limestones. Fossils noted in the Florence are: Dictyoclostus americanus, Derbyia crassa, Polypora sp., Archocella sp., Composita ovata, Rhombopora sp., crinoid columnals, Fenestella sp., Aviculopecten occidentalis, Meekella striatocostata and Stenopora sp. The average thickness of this limestone is about 22 feet. The Florence limestone forms a very prominent hillside bench topographically higher than that formed by the Wreford limestone. Outcrops of the Florence limestone are characterized by well-rounded shoulders usually high on the hills. Chert nodules are especially conspicuous on weathered surfaces.

The Florence limestone can easily be identified in the field by its cherty limestone, round shoulder benches and its position above the Wreford bench (For detailed descriptions see measured sections 28, 29, 30, 31, 32, 33, 34, 35, and 36).

Facies Changes in the Member. Shale partings are present in the top part of the Florence limestone west of Winkler and

southwest of Randolph but are absent north of Winkler and north of Stockdale. The Florence limestone is quite thick in the vicinity of Randolph, becomes thinner near Otto Dale, and is absent again in the southern area of Gateway.

Otto Shale Member

Name of the Member. The Otto shale (Table I) was named by Moore (1930) from exposures found near Otto in Marshall County, Kans. Prosser (1903) had previously included this shale as part of the Fort Riley limestone.

Areal Distribution. Outcrops of the Otto shale almost invariably are associated with those of the Fort Riley limestone (Plate I). Good exposures of the Otto shale were observed in a road cut in the NE¼ SW¼ sec. 29, T. 7 S., R. 7 E., in a stream bank in the SE¼ NW¼ sec. 24, T. 8 S., R. 6 E., and in a road cut in the NE¼ NE¼ sec. 12, T. 8 S., R. 7 E.

Description of the Member. The Otto shale is composed of two shales which ordinarily are separated by a layer of limestone lens. The shales are tan to fine-grey, silty, clayey, calcareous and are thin-bedded in structure. Several thin calcareous lenses usually are present in the upper shale, the middle one of which is hard, tan to grey, massive, and weathers to blocks and slip-like plates, and is tan to grey in color. The fossils observed in the Otto shale are: Pustrorbis americanus, Composita ovata, Polypora sp., Rhombopora sp., Fenestella sp., Spirifer cameratus, Derbyia occidentalis,

Orthis arcana, O. crucialis, O. petersensis, Tallinnella sp., Dalmanella sp., Leptaenisca sp., Rhytella strictopunctata, Schuchertella sp., and Lophospira bowsheri. The average thickness of this shale is considerably above 3 feet.

The Oneto shale is easily recognized in the field by its stratigraphic position between the Fort Riley and the Kanosh limestone and by the abundance of its fossils (for detailed descriptions see measured sections 31, 32, 33, 34, 35, and 36).

Facies changes in the member. The Oneto shale thickens slightly toward the northwest. The limestone beds described above is absent in the northeastern outcrop area and is replaced by calcareous shale or calcareous lenses. In the southeastern outcrop area, the shale is clayey silt and contains calcareous lenses in the uppermost part.

Fort Riley Limestone Member

Naming of the member. The Fort Riley limestone (Unit 5) was named by Swallow (1[illegible], p. 14). The type locality is Fort Riley, Geary County, Kans. Prosser (1[illegible], pp. 771-[illegible], [illegible]) described the Fort Riley as including the Florence limestone. Prosser later (1902) redefined the Fort Riley limestone to include the units now comprising the Kanosh limestone. Moore (1936) revised the terminology of the unit and included the Fort Riley limestone as the upper member of the Kanosh limestone. The Fort Riley limestone overlies the Oneto shale and underlies the Holmesville shale.

Areal Distribution. The Fort Riley limestone crops out in the central part of the county (Plate I). The principal outcrop belt of the Fort Riley extends from Cleburne, south to Randolph, and west to Keets where the belt leaves the county. Two outlines of the Fort Riley limestone are present two miles east of Ogden. Partial exposures of this limestone can be seen anywhere on this outcrop line. This limestone was examined in a road cut in the NW¼ NE¼ sec. 6, T. 7 S., R. 5 E., in an old quarry in the NE¼ NW¼ sec. 20, T. 9 S., R. 6 E., and in a road cut and stream bank in the center of the NE¼ sec. 4, T. 8 S., R. 6 E.

Description of the Member. The Fort Riley consists of massive limestones in which there may be shale partings. Some of the limestone ledges usually weather to form blocks, others to form plates. The limestones range from fairly hard to soft and are somewhat dolomitic. They are usually tan to gray-orange and weather tan-gray. A shale parting is usually present near the base of this limestone member. There are three "rim rock" ledges present in the Fort Riley at the type locality but any two were noted in Riley County exposures, one near the base and the other in the middle part of this limestone. The "rim rock" is a massive ledge of limestone and, being more resistant to weathering and erosion, it forms a conspicuous rim on the shoulders of many hillsides. This massive part varies from 3 to 6 feet thick and usually becomes porous when weathered. Fossils identified in the Fort Riley limestone are: Ambocoelia expansa, echinoid spines, Derbyia crassa, Dictyoclostus sp.,

crinoid columnals, Rhombopora sp., Fenestella sp., Meekella striatocostata, and brachiopod fragments. The average thickness of the Fort Riley limestone is about 33 feet.

The Fort Riley is easily recognized by its thickness, "rim rock" exposures, and stratigraphic position above the Florence limestone (For detailed descriptions see measured sections 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, and 42).

Facies Changes in the Member. The full thickness of the Fort Riley limestone was obtained in only one exposure (measured section 36) and variations in the thickness of the unit could not be determined. The part of the Fort Riley known as the "rim rock" is variable in its position within the member and may occur either at or near the base or in the middle part. In most exposures in this county, however, the "rim rock" occurs near the base of the Fort Riley. The "rim rock" attains a thickness of 6 feet near the center of the outcrop area and thins slightly toward both the north and south. This member is made up of soft, shale-weathering limestones in the northern outcrop area but becomes more massive and harder limestones in the southern outcrop area. It is difficult to define the contact between the Fort Riley and the shale that overlies it. The blue-gray color, which is characteristic of some exposures, is only local.

Doyle Shale

The Doyle shale (Table I) was named by Prosser (1902,

p. 718). The type locality is along Doyle Creek southwest of Florence, Marion County, Kans.

Pass (1929) included all beds below the Winfield limestone in the Doyle shale. Condra and Upp (1931) divided the Doyle shale into three members, in descending order: Gage shale, Towanda limestone, and Holmesville shale. Moore (1936, p. 12) dropped the name Doyle shale and raised the members proposed by Condra and Upp to formation rank. Moore, Frye, and Jewett (1944, p. 163) reverted to the classification of Condra and Upp, which decision is followed in this report.

Holmesville Shale Member

Naming of the Member. The Holmesville shale (Table I) was named by Condra and Upp (1931, p. 43). The type locality is 1½ miles west and ½ mile north of Holmesville, Gage County, Nebr. The Holmesville shale overlies the Fort Riley limestone and underlies the Towanda limestone.

Areal Distribution. Outcrops of the Holmesville shale almost invariably are associated with those of the Towanda limestone (Plate 1). Good exposures of the Holmesville shale were observed in road cuts in the NW¼ NW¼ sec. 6, T. 7 S., R. 6 E., in the [illegible] sec. 17, T. 7 S., R. 6 E., and northwest of Stockdale in the SW¼ SE¼ sec. 31, T. 6 S., R. 5 E. A portion of the Holmesville crops out in a road cut west of Keats in the NE¼ NE¼ SE¼ sec. 20, T. 9 S., R. 6 E.

Description of the Member. The Holmesville consists

predominantly of shales but usually contains one or more thin lenses of limestone most often present in the middle or lower part of the member. The shales are silty with some clay intermixed, are generally calcareous, and are gray, gray-green, olive drab and occasionally maroon. The maroon zone is usually in the middle part of the Holmesville but is absent in some exposures. The limestones are soft and usually argillaceous but locally may be dolomitic and arenaceous. The limestone lenses show pencontemporaneous folding in the northern part of the outcrop area and may contain microfossils. The average thickness of the Holmesville shale is about 19 feet.

The Holmesville shale is readily identified by its stratigraphic position between the Fort Riley and Towanda limestones (For detailed descriptions see measured sections 36, 37, 38, 39, 40, 41, and 42).

Facies Changes in the Member. The Holmesville shale is thickest in the center of the outcrop area and thins toward the northeast. Its thickness is a constant thickness in the southern half of the outcrop area. The lenses of limestone are thickest in the south but disappear in the area west of Keats and in the northeastern part of the county. The limestones correlate with three thin lenses southwest of Winkler.

Towanda Limestone Member

Naming of the Member. The Towanda limestone (Table I) was named by Moore (1920, p. 61). The type locality is in

the western part of the El Dorado oil field near Towanda, Butler County, Kans. Path (1921, p. 34) designated the Towanda limestone as a bed in the Doyle shale. Condra and Upp (1931, p. 44) designated the Towanda limestone as the middle member of the Doyle shale, the classification followed in this report. The Towanda limestone overlies the Holmesville shale and underlies the Cake shale.

Areal Distribution. The Towanda limestone forms the first prominent bench above the Fort Riley limestone (Plate I). It crops out in the northern half of the county and forms prominent benches east of Riley and west of Keats. This limestone crops out also near the southwestern corner of the county. The Towanda limestone is well displayed in road cuts west of Keats in the NE¼ SE¼ SE¼ sec. 29, T. 9 S., R. 6 E., in the SW¼ SE¼ sec. 16, T. 7 S., R. 5 E., and in the SE¼ SW¼ SW¼ sec. 17, T. 7 S., R. 6 E.

Description of the Member. The Towanda limestone is hard, dense in some zones, massive, and weathers to small blocks and plates. It is gray-orange to tan-brown and limonite stains and nodules appear abundantly on the surface. Very thin shale partings are locally present. Penecontemporaneous folding is exhibited in the southern and northern outcrops. Jewett (1939, p. 91) reported flint in this limestone in an exposure north of Leonardville. Microfossils are abundant in the basal ledge of this member. The average thickness of the Towanda limestone is about 12 feet.

It is easily recognized by its thickness, color, by small

blocks and plates found on the weathered surface, and its position above the Fort Riley limestone (For detailed descriptions see measured sections 36, 37, 38, 39, 40, 41, 42, 43, and 44).

Facies Changes in the Member. A tendency to become somewhat thicker toward the south is the only facie changes observed in the Towanda limestone as it is developed in Riley County.

Gage Shale Member

Naming of the Member. The Gage shale (Table I) was named by Condra and Upp (1931, p. 45) from outcrops between one and two miles south of the west side of Wymore, Gage County, Nebr. The Gage shale overlies the Towanda limestone and underlies the Stovall limestone.

Areal Distribution. Outcrops of the Gage shale almost invariably are associated with those of the Cresswell limestone (Plate I). The upper part of the Gage shale, in most outcrops, is exposed beneath the Stovall limestone. Good exposures of this shale were found in road cuts in the NE¼ SE¼ sec. 19, T. 7 S., R. 5 E., and in the NE¼ NE¼ sec. 25, T. 7 S., R. 5 E. The upper 15 feet of this shale were observed in a roadside ditch in the SW¼ NE¼ sec. 31, T. 9 S., R. 5 E.

Description of the Member. The Gage shale is predominantly maroon in the lower two-thirds and tan-gray to gray-green in the upper third. The maroon zone is mottled with green and contains some well-defined thin green lenses. This shale is composed of

silt with some clay and is thin-bedded to blocky. The maroon zones are noncalcareous but the others are at least slightly calcareous. Thin limestone lenses occur in the upper part of the Gage in the eastern part of its outcrop area. The following fossils are generally present in the upper tan-gray to gray-green shales: Derbyia crassa, D. cymbula, D. kooserensis, crinoid columnals, Stenopora sp., Polypora sp., Aviculopecten occidentalis, Rhombopora sp., echinoid spines, and Dictyoclostus americanus. The average thickness of this member is about 32 feet.

The Gage shale is recognized in the field by its position beneath the easily recognized Winfield limestone (For detailed descriptions see measured sections 42, 43, 44, 45, 47, 48, and 49).

Facies Changes in the Member. The Gage shale thickens toward the northwest. Two thin limestone lenses are present in this shale in an exposure northeast of Riley but only one limestone was found in an exposure in the northern part of the county.

Winfield Limestone

The Winfield limestone (Table I) was named by Prosser (1897, pp. 64-66). Its type locality is in the vicinity of Winfield, Cowley County, Kans. Prosser (1897, pp. 64-66), in naming this limestone, called it the Winfield concretionary limestone, and later (1902, p. 715) classified it as a formation.

Bass, (1929, p. 37) defined the Winfield limestone to include only the beds now known as the Cresswell limestone. Condra and Upp (1931, p. 49-51) divided the Winfield limestone into the Cresswell limestone in the upper part, the Grant shale in the middle part, and the Stovall limestone as the basal part. Moore (1936, p. 12) gave the name of Luta limestone member to the uppermost beds of the Winfield limestone. Moore, Frye, and Jewett (1944) accepted the definition of the Winfield limestone made by Condra and Upp and, in so doing, dropped the Luta as a separate stratigraphic unit.

Stovall Limestone Member

Naming of the Member. The Stovall limestone (Table I) was named by Condra and Upp (1931, p. 49). The type locality is in the valley bluffs of Doyle Creek southeast of the Stovall elevator and farm and 7 miles southwest of Florence, Marion County, Kans. The Stovall limestone overlies the Gage shale and underlies the Grant shale.

Areal Distribution. Outcrops of the Stovall limestone almost invariably are associated with those of the Cresswell limestone (Plate I).

Description of the Member. The Stovall limestone is hard, dense, massive, and weathers blocky. It is gray to tan-gray in fresh exposures and weathers light gray to tan. Chert nodules, usually iron stained, are abundant in this limestone. Fossils found in the Stovall are: crinoid columnals, Dictyoclostus

americanus, S. portlockianus, echinoid spines, Polypora sp., Composita ovata and brachiopod fragments. The average thickness of this member is about 1 foot.

This limestone is easily recognized in the field by the presence of a chert band and by its relative thinness (For detailed descriptions see measured sections 42, 43, 44, 45, 47, 48, and 49).

Facies Changes in the Member. The thickness of the Stovall limestone varies from 2.5 feet in the southern part of its outcrop area to 0.25 foot south of May Day in the northern part of the county where it may be represented by a line of chert nodules only. Although there are minor local variations in thickness, the regional tendency is toward thickening toward the southwest.

Grant Shale Member

Naming of the Member. The Grant shale (Table I) was named for Grant Township in Marion County by Condra and Upp (1931, p. 80). The type locality is between 5 and 6 miles north of Florence, Kans. This unit overlies the Stovall limestone and underlies the Cresswell limestone.

Areal Distribution. Outcrops of the Grant shale almost invariably are associated with those of the Cresswell limestone (Plate I).

Description of the Member. The Grant is silty and calcareous, thin-bedded to blocky shale. It is tan-gray and weathers

tan. The fossils observed in this shale are: Composita ovata, C. subtilita, Derbyia crassa, D. cymbula, Dictyoclostus americanus, D. portlockianus, crinoid columnals, echinoid spines, Polypora sp., Rhombopora sp., Allorisma terminale, Clonetes granuliferus, Aviculopecten occidentalis, and an excellent ostracod microfauna. The average thickness of the Grant shale is about 8.7 feet.

This shale is best recognized by its stratigraphic position in the Winfield limestone (For detailed descriptions see measured sections 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51).

Facies Changes in the Member. The Grant shale thickens and thins locally. The maximum thickness is 11.5 feet, in the southwest corner of the county, and the minimum thickness, 7.7 feet was found near the northern boundary of the county. Small secondary structures locally developed in the underlying Stovall limestone tend to give inaccurate indications of the thickness of the Grant shale. Fossils vary in abundance from one exposure to the next but that of a railroad cut west of Wale contains a most unusual abundance of fossils.

Cresswell Limestone Member

Naming of the Member. The Cresswell limestone (Table I) was named by Condra and Upp (1931, p. 51). The type locality is on the east side of a golf course in the NE¼ sec. 18, T. 34 S., R. 4 E. at the eastern edge of Arkansas City, Cresswell Township, Cowley County, Kans. As previously stated, Moore

(1936, p. 12) designated the Luta limestone as the top member of the Winfield limestone. Later, however, Moore, Frye, and Jewett (1944, p. 163) abandoned the Luta limestone as a unit in the Winfield limestone. There has been much controversy over the definition of the Cresswell and Luta limestones. Jewett (personnal communication) stated that the contact between these two limestones is seldom evident and favors dropping the term Luta entirely. Fresh exposures of the upper Winfield in this county exhibit no possible line of distinction between these two limestones and weathered outcrops only suggest a break between a massive basal limestone ledge overlain by a layer of badly weathered massive and platy limestone.

Areal Distribution. The Cresswell limestone outcrop band is west of a line extending from Keats to Swede Creek (Plate I). The Cresswell is covered by younger stratigraphic units in the vicinity of Leonardville and near the northwest corner of the county. The Stovall limestone and Grant shale are present almost everyplace that Cresswell crops out. The Cresswell limestone was studied in a road cut in the NE¼ SW¼ NE¼ sec. 31, T. 9 S., R. 5 E., in a railroad cut east of Bala in the NW¼ NW¼ NW¼ sec. 1, T. 9 S., R. 4 E., in a road cut in the NW¼ NW¼ sec. 25, T. 7 S., R. 6 E., and numerous exposures were noted in road cuts about 5 miles north of Leonardville.

Description of the Member. The Cresswell limestone is massive, medium hard, and dolomitic in part. It weathers blocky in the lower part and platy or blocky in the upper part. The upper part often becomes porous and cavernous when it is badly

weathered and usually contains numerous calcite-filled geodes. The Cresswell is tan-brown to light gray and usually weathers tan-gray. The following fossils occur only in its lower part: abundant of echinoid spines and numerous crinoid columnals and brachiopod fragments. The average thickness of the Cresswell limestone is about 12 feet. A prominent though irregular bench formed by the Cresswell limestone and a second smaller bench is developed when the full thickness of the limestone is present. Numerous sink holes occur in the Cresswell in the SW¼ sec. 6, T. 9 S., R. 6 E. In recent years, many of the older sinks have become filled in with silt and new ones have appeared.

The Cresswell limestone is easily recognized by its massive light gray limestone, abundance of echinoid spines in basal part, and its position above the easily identified Stovall limestone (For detailed descriptions see measured sections 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51).

Facies Changes in the Formation. No obviously significate facies changes were observed in the Cresswell limestone in this county.

Odell Shale

Naming of the Formation. The Odell shale (Table I) was named by Condra and Upp (1931, p. 59). The type locality is in a ravine and along highway cuts 1/8th of a mile south and 2½ miles east of Odell, Gage County, Nebr. Condra and Upp (1931, p. 49) designated the Odell shale as the basal member

of Interprise formation. Moore (1936, p. 18) elevated the Odell shale to the rank of a formation, which assignment is accepted here. The Odell shale overlies the Crouswell limestone and underlies the Krider limestone.

Areal Distribution. Outcrops of the Odell shale almost invariably are associated with those of the Herington limestone (Plate I). The Odell shale is well exposed in a road cut southwest of May Day in the SW¼ SW¼ sec. 36, T. 6 S., R. 4 E., and the upper part crops out in a road cut in the NW¼ SW¼ sec. 15, T. 6 S., R. 6 E. The upper part of the Odell shale usually is exposed beneath most of the outcrops of the Nolans limestone.

Description of the Formation. The Odell shale is gray-green to maroon, often mottled with green, in the lower part and tan-gray to gray-green in the upper part. This shale is a noncalcareous silt with some clay. The average thickness of the Odell is about 25 feet.

The Odell shale is easily recognized in the field by the thick maroon shales and its stratigraphic position below the easily identified Nolan limestone (For detailed descriptions see measured sections 52, 53, 54, 55, 56, and 57).

Facies Changes in the Formation. Limited observations indicate the thickening of the Odell shale toward the northwest. The thickness ranges from 21 feet in the southwestern part of Riley County to 33 feet in the northeastern part.

Nolans Limestone

The Nolans limestone was named by Moore (1936, pp. 5-9). The type locality is in the vicinity of the Nolans railway siding near Easons, Washington County, Kans. Moore (1936, p. 12) defined this formation as overlying the Odell shale and underlying the Pearl shale. The Nolans limestone is composed of the Herington limestone member in the upper part, the Paddock shale member in the middle part, and the Krider limestone member in the lower part.

Krider Limestone Member

Naming of the Member. The Krider limestone member (Table I) was named by Condra and Upp (1931, p. 60). The type locality is in a road cut ½ mile south of Krider, Gage County, Nebr. Condra and Upp (1931, p. 60) included the Krider limestone as the middle member of the Enterprise formation. Moore (1936, p. 12) discarded the Enterprise formation and placed the Krider limestone as the lower member of the Nolans limestone. The Krider limestone overlies the Odell shale and underlies the Paddock shale.

Areal Distribution. Outcrops of the Krider limestone almost invariably are associated with those of the Herington limestone (Plate I).

Description of the Member. The Krider is a soft, tan-gray, dolomitic limestone that has a sugary texture. This member is

usually composed of two thin limestones separated by a very thin shale parting but locally the Krider becomes a single massive bed of limestone. Fossils found in this unit are: Pleuropherus sp., Hyalina sp., Pseudoventis hawni and Aviculopecten occidentalis. The average thickness of this limestone is about 1.0 foot and so does not form a conspicuous hillside bench.

This limestone is best identified in the field by its stratigraphic position below the Herington limestone (For detailed descriptions see measured sections 52, 53, 54, 55, 56, 57, and 58).

Facies Changes in the Member. The thickness of the Krider limestone remains nearly constant in this county although it appears to be slightly less thick in the eastern part of its outcrop area.

Paddock Shale Member

Naming of the Member. The Paddock shale (Table I) was named by Condra and Upp (1931, p. 61) from outcrops in a road cut ½ mile south of Krider, Paddock Township, Gage County, Nebr. They listed the Paddock shale as the top member of the Enterprise formation. Moore (1936, p. 12) later discarded the Enterprise as a formational unit and designated the Paddock shale as the middle member of the Nolans formation. The Paddock shale overlies the Krider limestone and underlies the Herington limestone.

Areal Distribution. Outcrops of the Paddock shale almost invariably are associated with those of the Herington limestone (Plate I).

Description of the Member. The Paddock is a thin-bedded to blocky gray to olive drab shale that weathers tan. It is composed either of noncalcareous clay or calcareous silt. There is a conspicuous calcareous zone in the southern outcrop area in the lower part of the member. Molds of Aviculopecten occidentalis occur on some of the bedding planes. The average thickness of this unit is about 13 feet.

The Paddock shale is easily recognized by its nearly constant thickness, generally gray color, and its stratigraphic position within the Nolans limestone (For detailed descriptions see measured sections 52, 53, 54, 55, 56, 57, and 58).

Facies Changes in the Member. The thickness of the Paddock shale varies somewhat over the county. There is evidence of slight thickening toward the northwest and thinning toward the southeast. The Paddock is clayey and noncalcareous in the southern part of the county but becomes progressively more silty and calcareous toward the north.

Herington Limestone Member

Naming of the Member. The Herington limestone (Table I) was named by Beede (1909, p. 253) and included as a part of the Marion stage. The type locality is in the vicinity of Herington, Dickinson County, Kans. Bass (1929) abandoned the Marion

formation as a stratigraphic unit and elevated the Herington limestone to the rank of a formation on the Sumner group. Moore (1936, p. 12) later defined the Herington limestone as the top member of the Nolans limestone. The Herington limestone overlies the Paddock shale and underlies the Wellington formation.

Areal Distribution. The Herington limestone is exhibited in numerous exposures in the western half of the county (Plate I). This limestone crops out along the Geary-Riley County boundary and its area of outcrop extends as far east as Riley, Walsburg, Randolph, and Fleburne. The upper part of the Odell shale, the Krider limestone, and the Paddock shale are present in almost all of the outcrops in which the Herington limestone appears. Good sections of the Herington were noted in road cuts in the NE¼ NE¼ NE¼ sec. 8, T. 9 S., R. 8 E., in the NE¼ NW¼ sec. 3, T. 9 S., R. 6 E., in the SE¼ SW¼ sec. 1, T. 8 S., R. 5 E., the NW¼ NE¼ sec. 14, T. 6 S., R. 4 E., and in the SW¼ NE¼ sec. 30, T. 6 S., R. 4 E.

Description of the Member. The Herington is a medium-hard dolomitic limestone in which there are thin shale partings. The limestone is massive, porous, weathers blocky to platy, and has a sugary texture. The Krider limestone resembles the Herington limestone. Fossils observed in the Herington are: Pleuropleurus sp., Worthenia sp., Pseudomentis kansasi, Aviculopecten occidentalis and Loxonema sp. The average thickness of this limestone is about 7 feet.

The Herington limestone is easily recognized by its

thickness, color, by its soft dolomitic texture, molluscan fauna, and by the prominent hillside bench it forms (For detailed descriptions see measured sections 52, 53, 54, 55, 56, 57, 58, 59, and 60).

The Leonardian series (Table I) includes strata from the top of the Nolans limestone to the base of the Whitehorse sandstone. The Leonardian series is composed of the Nippewalla and Sumner groups of which only the basal part of the older, underlying Sumner group crops out in Riley County.

The Sumner group (Table I) was named by Cragin (1896). A thickness of about 50 feet of the Wellington shale represents this group in Riley County.

Wellington Shale

Naming of the Formation. The Wellington shale (Table I) was named by Cragin (1896, pp. 35-36) from outcrops in the vicinity of Wellington, Sumner County, Kans.

Cragin (1896, pp. 3, 16) described the Wellington shale and classified it as the top formation of the Big Blue series and Prosser (1897, pp. 64-66) included the same shale as a part of the Marion formation. Numerous authors included the Wellington shale in the "Salt measures" and others defined it as a member of the Marion formation. Bass (1926) redefined this sequence of strata and included all beds between the "Red

beds" and the Herington limestone in the Wellington shale, thus discarding the "Marion formation". Moore (1936, p. 12) divided the Herington limestone into the Wellington shale at the top, the Donegal limestone in the middle, and the Pearl shale at the base. Moore, Frye and Jewett (1944, p. 100) classified the Wellington shale as the basal formation of the Sumner group. This formation overlies the Nolans limestone and in one exposure in Riley County it underlies the Dakota sandstone but elsewhere it is overlain by Quaternary formations.

Areal Distribution. The Wellington shale crops out locally in areas that lie east and northwest of Leonardville, and somewhat more extensively near the northwestern corner of the county (Plate I). This formation was studied in road cuts in the SW¼ SE¼ sec. 6, T. 9 S., R. 6 E., and the NW¼ NW¼ sec. 13, T. 9 S., R. 5 E., as well as in a stream bank in the SW¼ NW¼ sec. 1, T. 6 S., R. 4 E.

Description of the Formation. The part of the Wellington exposed in this county consists of tan-gray shales in the upper and lower part and maroon, gray and green shales in the middle part. The shales are thin-bedded to blocky and are mostly silty and calcareous. There is a tan-brown limestone at the top of most exposures of this shale. This limestone is hard, fine-grained, massive, and weathers porous to platy. Purple banding appears in this limestone in the northeastern part of the outcrop area. The limestone bed is thought to be the equivalent to the "Hollenberg limestone" a unit cited extensively by earlier writers. Recently, however, the Kansas Geological

Survey has discarded the member units of the Wellington shale. Only fragments of fossils were found in this limestone. The Wellington shale attains maximum thickness in this county of about 50 feet.

The Wellington shale can best be identified in the field by its stratigraphic position above the Harrington limestone and by the "Hollenberg" limestone present in the top part of most outcrops (For detailed descriptions see measured sections 39 and 40).

Facies Changes in the Formation. The shale beneath the "Hollenberg" zone becomes appreciably thicker toward the south.

STRATIGRAPHY OF THE CRETACEOUS SYSTEM

The Colorado group is composed of the following formations, in descending order: Niobrara chalk, Carlile shale, Greenhorn limestone, Graneros shale, and Dakota sandstone. Only the Dakota sandstone crops out in Riley County.

Dakota Sandstone

Naming of the Formation. The Dakota sandstone (Table I) was named by Meek and Hayden (1862, pp. 419-420). The sandstones of the Dakota are the youngest consolidated rocks cropping out in Riley County. The Dakota sandstone immediately overlies the lower part of the Bellington shale.

Areal Distribution. The only outcrops of the Dakota sandstone in Riley County are exposed west of Bodaville in secs. 1 and 2, T. 6 S., R. 4 E. (Plate I). A good exposure of this formation was studied in a road cut in the SW¼ NW¼ sec. 1, T. 6 S., R. 4 E.

Description of the Formation. The Dakota is represented locally by sandstones and conglomerates. The formation is composed of fine to coarse sand-size grains of quartz, predominantly, cemented by interstial deposits of calcium carbonate. The conglomeratic zones are composed of iron-cemented sands, iron stone concretions, and clay balls. The beds of sandstone are massive, weather blocky to nodular, and show some cross-bedding. Both the conglomerates and sandstones are dark-brown

in color. The exposed thickness of the Dakota varies from 2 to 5 feet and the formation can easily be recognized in the field by its sandy lithology (For detailed description see measured section 60).

Facies Changes in the Formation. No facies changes were observed in that portion of the Dakota sandstone which crops out in this county.

Igneous Intrusives

There are three exposures of igneous rock in Riley County which are located in the NW¼ NE¼ sec. 6, T. 9 S., R. 5 E., in the SE¼ NE¼ sec. 22, T. 8 S., R. 5 E., and in a stream cut in the NW¼ SE¼ sec. 23, T. 8 S., R. 6 E. (Plate I).

The exposure located in the NW¼ NE¼ sec. 6, T. 9 S., R. 5 E., is known locally as the Dale plug. R. C. Moore and W. P. Haynes (1920, pp. 183-187) described the petrography of this intrusion as a serpentinized, carbonized, porphyritic, peridotite breccia containing numerous shale xenoliths, and phenocrysts of altered olivine with some altered augite and biotite. The groundmass is essentially serpentine and calcite with considerable chromite and some magnetite. This rock gives a physiographic expression of a small knoll 15 feet high and about 200 feet long.

The other two intrusives, differ from the one above, by the presence of small garnets and numerous limestone, shale, and chert fragments. There are no physiographic expressions

of these two intrusives.

The age of these igneous rocks is believed to be late Cretaceous.

STRUCTURAL GEOLOGY

The purpose of this section on structural geology is to record new structures located in the course of the field work in Riley County, to compile a listing of structures previously recorded in the county, and to indicate the relationship of stratigraphy to existing structures.

The consolidated rocks of Paleozoic age are included in the Prairie Plains monocline and the north Kansas Basin (J. M. Jewett, 1941, p. 99). These rocks show a regional dip toward the northwest of about 10 feet to a mile. The two major structures present in this county are the Abilene anticline and the Salina dome. The Salina dome is present in the vicinity of Leandale and causes the Pennsylvanian rocks to crop out in that area. The dome is the result of supratenuous folding of strata over the buried Nemaha Ridge and its apex is believed to be located about 1½ miles south of Leandale. The dip of the Permian strata on the west flank of the dome is clearly shown along the south valley wall of the Kansas River in the SE¼ NE¼ sec. 23, T. 10 S., R. 9 E. and a steep southward dip can be seen in the strata south of Leandale in secs. 15, 16, 17, and 18, T. 11 S., R. 9 E. as well as in a small knoll capped by the Americus limestone in sec. 9, T. 11 S., R. 9 E. A steep southeasterly dip is evident in the Grenola and Feattie limestones along the east side of sec. 22, T. 11 S., R. 9 E. Two small overthrust faults were observed south of Leandale. One of these is a small overthrust fault, discovered by Neff

(1949), affecting the Tarkio limestone as it is exposed in a stream bank in the E½ SW¼ NW¼ sec. 5, T. 11 S., R. 9 E. The other known overthrust is exhibited in the Caneyville limestone in an outcrop in a stream bank in the SW¼ SW¼ sec. 7, T. 11 S., R. 9 E.

Major faults occur in secs. 12, 13, 14, 25, 26, and 36, T. 11 S., R. 8 E. (Plate I). Eight faults are mapped in this area and the maximum displacement, about 10 feet, is developed along a normal fault in sec. 13, T. 11 S., R. 8 E. Strata from the Neva limestone to the Threemile limestone have been displaced by this mile-long fault. Another major fault, which is about 1½ miles long and shows a displacement of about 5 feet, was found in secs. 26 and 36, T. 11 S., R. 8 E. All of the faults in this area trend toward the northwest.

The Abilene anticline is the largest of the major structures in Riley County. The axis of this anticline extends along a line from Marshall County south through Winkler, west of Leonardville, and southwest of Zeandale. This anticline is responsible for the outcrop of older Permian strata in areas in which they would otherwise be covered by younger overlying rocks. Steep southeasterly dips of the Fort Riley limestone were observed on a hillside in the southern part of sec. 1, T. 6 S., R. 6 E. Other changes in the regional dip of the Fort Riley limestone were found along north Otter Creek and, in the Florence limestone, north and northeast of Winkler. Significant changes in dip have been observed in the vicinity of Winkler and along Fancy Creek (Plate I).

A small syncline in the northwestern corner of Riley County was discovered in the course of this field work and is probably responsible for the continued existence of the Dakota outlier. This structure is also reflected in the Nolans limestone cropping out west of Bodeville. Other structures related to the Abilene anticline were observed southwest of Winkler. Reversals of regional dip are well displayed in secs. 2, 10, 11, 14, 15, 21, 22, and 23 and parts of adjacent sections in T. 7 S., R. 5 E. A steep eastward dip, possibly the west limb of a syncline is responsible for the presence of the Wellington shale in sec. 6, T. 8 S., R. 6 E. and secs. 1, 2, 3, 10, 11, 12, and 13, T. 8 S., R. 5 E. (Plate I).

Another structure, also a part of the Abilene anticline, extends from Bala south to the Geary County line. The dip in this area is toward the southeast. This fold probably accounts for the presence of the Nolans limestone in this area (Plate I).

There is some evidence that a small dome may be present in secs. 23 and 24, T. 9 S., R. 4 E.

Small faults and flexures were observed in most exposures of the Stovall limestone and some of the outcrops of the Krider limestone but are not usually reflected in the thicker limestones above and below these units. A small overthrust fault occurs in the Stovall limestone in a railway cut in the NW¼ NW¼ NE¼ and other similar minor structures are far too numerous to be cited here. A small normal fault was found in the Gage shale in the NE¼ SE¼ sec. 19, T. 7 S., R. 3 E. A possible

extension of the Abilene anticline is reflected in the Winfield limestone south of Riley.

PALEOGEOGRAPHY

Pennsylvanian Period

The seas of the Pennsylvanian period covered almost all of midcontinental United States. In Kansas outcrops of the rocks deposited in these seas are restricted to the eastern part of the state but extend as far west as the southeastern part of Riley County. The small area of outcrop in Riley County affords little evidence of regional variation in the character of the rocks of the Pennsylvanian system and is productive of no more than meager indication of changes in the marine depositional environment of the midcontinental area.

The bulk of the sediments deposited in the Pennsylvanian seas apparently was eroded from land areas toward the east and southeast. The shales of the Pennsylvanian system in Riley County are either constant in thickness or thicken slightly toward the northeast whereas the limestone thicken slightly toward the southwest or, too, are constant in thickness. Most of the shales in the local area of outcrop change from calcareous in the southwest to noncalcareous in the northeast. This evidence indicates that the shoreline lay northeast of Kansas during most of late Pennsylvanian time. The shoreline of the Pennsylvanian seas fluctuated to the extent that alternating thick shales and thin limestone were caused to be deposited over this region. The thickness of the Willard shale and

Tarkio limestone indicates that the shoreline was relatively stable for a longer interval during the deposition of each of these units. None of the shales exhibits any evidence of marked tectonic disturbances during the time of deposition. The color of the shales varies from tan-gray to gray, with thin interbedded gray-green zones and may indicate depth of deposition, a factor of minor flucuations in the shoreline of the sea. An important series of oscillations of the Pennsylvanian shoreline apparently occurred during the time of deposition of the upper part of the French Creek shale and the Caneyville limestone. A coal lens, indicative of a swamp environment, occurs near the top of the French Creek shale. The shoreline must then have lain to the west of this region inasmuch as swamps are non-marine. A carbonized zone, which contains numerous wood fragments, occurs in the top part of the Caneyville limestone. This may indicate another short-lived retreat of the Pennsylvanian shoreline toward the west or may represent an unusual influx of stream-carried plant material into the sea. The argillaceous Brownville limestone shows that the shoreline lay to the east of the close of the Pennsylvanian period.

Permian Period

The seas of the Permian period for the most part, were restricted, in the United States, to the midcontinental region centered about Texas, Oklahoma, and Kansas. All of Kansas,

except possibly the extreme southeastern part of the state, was submerged beneath marine waters at the beginning of the period. The rocks deposited in these seas, however, crop out only in a wide belt extending from Marysville toward the south and southeast across the state. Permian strata conspicuously exposed over all of Riley County except the southeastern part from which they were subsequently eroded. These same strata are concealed beneath Cretaceous and younger rocks throughout the north-central and western parts of the state.

The evidence recorded in this county is only local indication of the paleogeographic events that ensued during the time of deposition of the Permian sediments. It can not portray the complete regional picture but should contribute to it. An example of the way in which a stratigraphic unit studied only over a small area may lead to an inaccurate regional interpretation is found in the Eskridge shale as it is developed in Riley County. This shale indicates, by its thickness, that the Permian shoreline was toward the north or northwest, but fossil leaves, lenses of coal, and dark-colored littoral shales, which characterize this shale in Morris County, clearly indicate the shoreline to have been toward the south or southeast. Complete regional information must be obtained to interpret accurately the paleogeographic conditions extant during Permian times.

The bulk of the Permian sediments deposited in this region came from the land areas toward the east and southeast. The thick limestones and well developed faunas of the Wolfcampian

series indicate deposition in quiet offshore waters. The thick red and green shales indicate deposition only a short distance from the shoreline and very likely include some non-marine zones. Occasional local thin seams of coal, as in the West Branch shale in Pottawatomie County and the Blue Springs shale in Geary County, indicate deposition in coastal swamps. Such oft-repeated changes in the lithology of the Permian strata are conclusive evidence of a widely and rapidly oscillating shoreline.

The data on variations in the thickness of the local Permian units also lead to the concept of a shifting shoreline. Most of the limestones are either constant in thickness or thicken toward the south and the shales thicken toward the north or are constant in thickness. Directional thickening of the following limestone and shale units indicates that the shoreline during their deposition lay immediately to the north of this area: Falls City limestone, West Branch shale, Howe limestone, Florena shale, Stearns shale, Kiss limestone, Funston limestone, Speiser shale, Threemile limestone, Ft. Riley limestone, Stovall limestone and the Herington limestone. Directional thickening of the Hooser and Blue Rapids shales indicates a southeastern shoreline and the units which indicate a southern shoreline are the Aspinwall limestone, Burr limestone, Salem Point shale, Neva limestone, Havensville shale, Wymore shale, and Grant shale. Evidence of a southwest shoreline is recorded in the Easly Creek and Gage shales. Those units which indicate a northwestern shoreline are the Eskridge

shale, Merrill limestone, Odell shale and Paddock shale.

Fairly definite evidence of the axis of a local Permian embayment during Havensville time is found in the area from Winkler to Randolph and extending toward the east into Pottawatomie County. This axis is clearly indicated in the Havensville shale, which in this area, includes many thick beds of limestones most of which grade laterally into shales toward the north and south. In the vicinity of Winkler, the uppermost 6 feet of the Havensville shale is all limestone. Evidence of the axis of a local embayment in the vicinity of Stockdale is found in the Schroyer and Florence limestones but additional field study in adjacent areas will be required to establish the axis of this embayment more accurately.

The evidence of numerous minor retreats and advances of the Permian shoreline is clearly reflected in the shales and limestones of this area. Such minor oscillations undoubtedly occurred many times during the deposition of a single stratigraphic unit. The major phases in the retreat and advance of the shoreline is shown by alternating limestone and shales. Sharp, clearly defined contacts between most limestones and shales indicate abrupt changes in the depositional environment. But gradual changes are reflected in some of the local units in the presence of transitional zones of the contacts of limestones and shales. The Newby shales show evidence of a gradual advances and two sharp retreats of the shoreline.

Slow spreading of Permian seas is indicated at the end of the time of deposition of the Cloverna, Blue Rapids, and Blue

Springs shales. Long intervals of uniform deposition, with only minor environmental changes, are evident in the units deposited above the Holmesville shale and below the Wellington shale. Such evidences as these appear to indicate quite conclusively that the shoreline of the early Permian embayment in this part of Kansas oscillated widely and irregularly.

Although only suggested by studies over an area as small as Riley County, the same evidence indicates a general shifting of the shoreline toward the south or southwest in the later stages of the Wolfcampian epoch. It is hoped that the investigation of the paleogeography of Kansas during the Permian period can be continued beyond the limits of Riley County in order that the regional pattern may be more accurately established.

Cretaceous System

The seas of the Cretaceous period covered most of the midwestern part of the United States including all of Kansas but the southeastern part. An outlier of the Dakota sandstone, which is the oldest formation of the upper Cretaceous, Gulfian series, is present in northwestern corner of Riley County and lies nonconformably on the Wellington shale. The Dakota presumably was stream deposited on a coastal plain at the margin of the spreading late Cretaceous sea. The coarse conglomeratic zone containing ellipsoidal to spheroidal particles indicates deposition by fairly strong water currents and the

beds of sandstone probably were laid down by currents of moderate transporting power. The scant development of the Dakota sandstone in Riley County precludes a more complete paleogeographic interpretation.

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APPENDIX

Section 1

This section from the Elmont limestone to the Auburn shale, inclusive, is exposed in a road cut and ditch in the center of the NW¼ sec. 32, T. 10 S., R. 9 E.

	Feet
Soil, silty; dark; rock fragments at base.	1. ±
Elmont limestone. (2.0 feet)	
Limestone, hard, dense; gray, weathers tan; massive, weathers blocky; fractures at nearly 90°; limonite stains and nodules. Fusulinids abundant, crinoid columnals, echinoid spines, Neospirifera sp., Bellerophon sp., and fossil fragments. . . .	2.0
Harveyville shale. (15.2 feet)	
Shale, clayey, slightly calcareous; gray-green; thin-bedded to blocky; calcareous nodules and limonite stains in upper part.	5.5
Covered interval.	9.7
Reading limestone. (2.1 feet)	
Limestone, hard, dense; gray, weathers tan; massive, weathers irregularly; limonite stains and nodules. Crinoid columnals, Rhombopora sp., echinoid spines, fusulinids, and numerous brachiopod fragments.	0.4
Limestone, hard, dense; gray, weathers tan; massive, weathers irregularly; limonite stains and nodules. Crinoid columnals, Euomphalus sp., Neospirifera sp., Rhombopora sp., echinoid spines, fusulinids, Loxonema sp., and numerous brachiopod fragments.	.5
Limestone, hard, dense; gray, weathers tan; massive, weathers blocky and irregularly; limonite specks, limonite stains, and nodules in upper part. Echinoid spines, crinoid columnals, Rhombopora sp., fusulinids, Meekella striatocostata, and sharks' teeth.	.6
Limestone, hard, dense; gray, weathers tan; massive, weathers irregularly; limonite specks in upper part. Ambocoelia sp., Loxonema sp., crinoid columnals, echinoid spines, Bellerophon sp., and numerous fossil fragments.	.6
Auburn shale. (6.6 feet exposed)	
Shale, silty, calcareous; tan-gray; blocky; iron stains on fracture planes.	.8
Limestone, argillaceous in middle, hard, dense; dark gray, weathers tan; thin-bedded; lenticular; porous; limonite-stained.	.5

Shale, silty, with some clay, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; carbon stains on bedding and fracture planes, calcareous nodules in upper part. 8.3

Base covered.

Section 2

This section from the Tarkio limestone to the Harveyville shale, inclusive, is exposed in a stream cut in the NE¼ NW¼ sec. 5, T. 11 S., R. 9 E.

	Feet
Soil, silty, dark; some chert gravel.	2 ±
Tarkio limestone. (14.3 feet)	
Limestone, hard; gray-orange, weathers brown; massive, weathers irregularly; porous; small, calcareous nodules in lower part. Large fusulinids very abundant, crinoid columnals, and brachiopod fragments. Fossils weather lighter than matrix. .	5.6
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded; contains calcareous nodules, deeply limonite-stained in lower part. Crinoid columnals, fusulinids, and brachiopod fragments. .	0.8
Limestone, shaley; gray-orange, weathers tan; thin lenticular limestone with lenticular shale partings. Crinoid columnals and fossil fragments. . .	.65
Limestone, hard, dense, somewhat crystalline; light gray to gray-orange, weathers tan-gray; massive. Large fusulinids, which weather lighter than the matrix, are exceedingly abundant in the middle and lower parts. Crinoid columnals, Axophyllum rude, Lophophyllum proliferum, echinoid spines, Composita sp., and other brachiopod fragments are also present.	7.25
Willard shale. (27.6 feet)	
Shale, clayey with some silt, calcareous; blue-gray, to tan-gray; thin-bedded to blocky; limonite stains on fracture and bedding planes. . . .	27.6
Elmont limestone. (2.3 feet)	
Limestone, hard, dense; blue-gray, weathers light blue-gray; massive, weathers to large elongated blocks; iron stains on fracture planes. Worm burrows? in the upper part, Marginifera sp., large and small fusulinids abundant, crinoid columnals, Ambocoelia sp., Composita sp.	2.3
Harveyville shale. (4± feet)	
Shale, blue-gray, weathers light gray; thin-bedded. (exposed only beneath waterfall).	4 ±

Section 3

This section from the Dover limestone to the Auburn shale, inclusive, is exposed in a road cut in SW¼ NW¼ NW¼ sec. 27, T. 10 S., R. 9 E.

	Feet
Soil, silty, gray; rock fragments.	2 ±
Dover limestone. (2.5 feet exposed)	
Limestone, only blocky and nodular fragments, gray, weathers light gray. Fusulinids abundant, algal nodules common. Forms small hillside bench. . .	2.5
Langdon shale. (16.0 feet)	
Covered interval.	6.5
Shale, clayey with some silt, noncalcareous; blue-gray, weathers gray-green; thin-bedded; limonite stains on bedding planes, limonite plates on the weathered surface.	9.5
Maple Hill limestone. (0.9 feet)	
Limestone, hard; gray-brown, weathers tan; massive, weathers irregular plates and blocks; fractures at about a 30° angle from the vertical. Crinoid columnals, small and large fusulinids abundant, brachiopod fragments, the fossils weather the same color as the matrix. Forms small, but not too conspicuous, hillside bench.	0.9
Wamego shale. (14.8 feet)	
Shale, clayey, calcareous; tan to gray, weathers orange-gray; thin-bedded; contains abundance of limonite stains and plates, thin limonite plates abundant on the weathered surface.	14.8
Tarkio limestone. (11.2 feet)	
Limestone, hard; brown, weathers gray-brown; massive, fractures into irregular blocks and fragments; limonite-stained. Large fusulinids abundant, algae, crinoid columnals, some brachiopod fragments and echinoid spines. This limestone is not well exposed as a hillside bench, but tapers down to the more resistant underlying limestone bed.	5.5
Limestone, hard, very dense in upper part; tan-brown, weathers gray-brown; massive, weathers in large irregular blocks; stylolites present in upper part. Large fusulinids very abundant, crinoid columnals, echinoid spines. The upper 3 feet is nonfossiliferous. Forms very prominent hillside bench with large blocks slumped down upon the underlying shale.	5.7

Willard shale. (20.1 feet)
Shale, clayey, noncalcareous; tan-gray to tan, weathers tan; thin-bedded to blocky; limonite stains on bedding planes. 20.1

Elmont limestone. (1.9 feet)
Limestone, hard, dense; blue-gray, weathers light blue-gray; massive, fractures at nearly 45° to elongated blocks; some limonite stains on weathered surface, with a calcareous, limonite-stained zone, 0.2 foot thick, present at very top. Small fusulinids common, large fusulinids, small crinoid columnals, few echinoid spines, few brachiopod fragments. Forms small hillside bench. . . 1.9

Harveyville shale. (16.1 feet)
Shale, clayey, slightly calcareous; gray-green; thin-bedded to blocky; some limonite stains on bedding planes. 16.1
Covered interval. 2.2

Reading limestone. (2.0 feet)
Limestone, hard, dense; blue-gray, weathers tan-gray; three definite beds of the same lithology; massive, weathers to irregular blocks; some limonite stains. Crinoid columnals, brachiopod fragments, echinoid spines, Chonetes granuliferus, Derbyia crassa, Rhombopora sp., and some algae. . 2.0

Auburn shale. (0.5 feet exposed)
Shale, clayey, noncalcareous; dark gray, weathers gray; thin-bedded; some limonite stains on bedding planes. 0.5

Base covered.

Section 4

This section from the Dry shale to the top of the Tarkio limestone, inclusive, is exposed in a tributary in the center of the SW¼ sec. 32, T. 10 S., R. 9 E.

	Feet
Soil, silty; dark; some colluvium.	1 ±
Dry shale. (3.3 feet)	
Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded; heavily limonite-stained with some limonite nodules and numerous calcareous nodules. Algae and large fusulinids abundant, small fusulinids, crinoid columnals, Derbyia sp., Rhombopora sp. (This shale might be a transitional phase of the upper part of the Dover limestone rather than true Dry shale.).	3.3
Dover limestone. (2.7 feet)	
Limestone; basal part hard; gray, weathers light gray; massive, weathers nodular; somewhat limonite-stained. Algae and large fusulinids abundant, some small fusulinids, crinoid columnals, Derbyia sp., small Neospirifera sp., Rhombopora sp., Mustedia mormoni, and fossil fragments.	2.7
Langdon shale. (2.5 feet)	
Shale, silty, calcareous; gray-green, weathers light green; blocky; some limonite and carbon stains. .	2.5
Maple Hill limestone. (1.2 feet)	
Limestone, hard; gray, weathers tan; massive to blocky, weathers to irregular plates in the upper part; limonite-stained. Small fusulinids abundant, large fusulinids common, crinoid columnals, Amblocoelia sp., echinoid spines. Forms small, inconspicuous hillside bench.	1.2
Wamego shale. (12.2 feet)	
Shale, silty, calcareous; blue-gray to tan-gray, weathers tan; thin-bedded to blocky; heavily limonite-stained, some carbon stains, numerous limonite plates on weathered surface.	12.2
Top of Tarkio limestone.	

Section 5

This section from the Grandhaven to the top of the Tarkio limestone, inclusive, is exposed in a ditch in the NE¼ sec. 5, T. 11 S., R. 9 E.

	Feet
Soil, silty; dark.	1 ±
Grandhaven limestone. (1.4 feet)	
Limestone, hard; gray, weathers tan; massive, weathers to irregular plates. Crinoid columnals abundant, Allorisma terminale, Aviculopinna peracuta, Chonetes granulifera, small and large fusulinis.	1.4
Dry shale. (11.9 feet)	
Shale, silty, very calcareous; tan to gray, weathers gray; thin-bedded to nodular; contains thin, gray-brown limestone lenses; iron stains on bedding planes.	2.5
Shale, clayey, noncalcareous; gray-green, weathers gray; thin-bedded; limonite-stained.	3.6
Shale, silty, calcareous; gray to yellow-gray, weathers yellow-tan; thin-bedded; contains some calcareous nodules; iron-stained.	4.3
Shale, silty, very calcareous; gray-green, weathers tan-gray; nodular; iron-stained. Dictyoclostus sp., Juresania nebrascensis, echinoid spines and plates, Ambocoelia sp., Chonetes granulifera, Derbyia crassa, crinoid columnals, Rhombopora sp. (This shale might be a transitional phase of the upper part of the Dover limestone rather than true Dry shale.).	1.5
Dover limestone. (1.6 feet)	
Limestone, somewhat argillaceous; gray, with a greenish tint, weathers light gray; massive, weathers nodular to blocky; iron stains on bedding and fracture planes. Algae abundant, fusulinids common, and echinoid spines.	1.6
Langdon shale. (13.6 feet)	
Shale, (partly covered by slump), clayey, noncalcareous; greenish-gray, weathers light gray; thin-bedded; some limonite stains.	13.6
Maple Mill limestone. (0.8 feet)	
Limestone, (poorly exposed), hard, dense; gray-brown, weathers tan; massive, weathers irregularly. Crinoid columnals abundant, large and small fusulinids abundant.	0.8

Bamego shale. (11.6 feet)

Shale, clayey, noncalcareous; blue-grey to tan, weathers tan; thin-bedded; numerous limonite plates on the weathered surface. 5.5

Covered interval. 6.1

Tarkio limestone. (1.5 feet exposed)

Limestone, hard, somewhat dense; tan-brown, weathers brown; massive, weathers platy. Large fusulinids abundant. 1.5

Section 6

This section from the Friedrich shale to the Langdon shale, inclusive, is exposed near the head of a tributary in the SW¼ SE¼ sec. 20, T. 10 S., R. 9 E.

	Feet
Soil, silty and clay; dark; some weathered chert gravel.	2 ±
Friedrich shale. (0.9 feet exposed)	
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; thin-bedded; iron stains on bedding planes.	0.9
Grandhaven limestone. (4.7 feet)	
Limestone, somewhat argillaceous, light gray-green, weathers light gray; massive, weathers with rounded corners. Numerous crinoid columnals which weather white on the surface, small and large fusulinids, Chonetes granulifera.	.7
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; blocky; limonite stains on fracture planes.	2.1
Limestone, hard, dense; brown, weathers light brown; massive, weathers to irregular plates; limonite stains abundant. Crinoid columnals, Derbyia sp., and Echinoconchus sp.	1.9
Dry shale. (6.8 feet)	
Covered interval.	6.8
Dover limestone. (3.6 feet exposed)	
Limestone, soft, argillaceous, certain areas are hard; gray-green, weathers light gray; massive, weathers to irregular blocks and nodules; the middle zone becomes hard, brown, and massive; iron stains on fracture planes. Small and large fusulinids and algae abundant, Aviculopecten occidentalis, Meekella striatocostata, and echinoid spines. The middle part resembles the Farkio limestone in color. The Dover limestone forms small hillside bench.	3.6
Langdon shale. (5.5 feet exposed)	
Shale, silty, noncalcareous; gray-green, weathers tan-gray; thin-bedded; limonite and iron stains on bedding and fracture planes.	5.5
Base covered.	

Section 7

This section from the Indian Cave sandstone member of the Towle shale to the Grandhaven limestone, inclusive, is exposed in a road cut in the NE¼ SW¼ sec. 30, T. 10 S., R. 9 E.

	Feet
Soil, silty, with limestone fragments; gray.	2 ±
Towle shale. (41.0 feet exposed)	
Indian Cave sandstone member. (41.0 feet exposed)	
Sandstone, fine quartz grains; tan to tan-brown; thin-bedded and cross-bedded; numerous mica flakes; iron cemented, limonite stains and plates numerous, limonite concretions, some carbon stains.	41.0
Covered interval.	12.2
Friedrich shale. (5.6 feet exposed)	
Shale, clayey, calcareous; gray, weathers light gray; blocky; some calcareous nodules.	5.6
Grandhaven limestone. (2.8 feet)	
Limestone, hard, dense; tan-brown; massive, weathers blocky to nodular. *Dictyoclostus* sp., *Fenestella* sp., *Acanthocoelia* sp., crinoid columnals, *Composita* sp., *Marginifera* sp.	2.8
Base covered.	

Section 9

This section from the Aspinwall limestone to the Dry shale, inclusive, is exposed in a stream bank in the [illegible] sec. 9, T. 11 S., R. 9 E.

	Feet
Aspinwall limestone. (0.6 feet exposed)	
Limestone, hard, somewhat crystalline; gray-brown, weathers tan-brown; massive, weathers in irregular blocks. Crinoid columnals, Dictyoclostus sp., Fenestella sp., Ptenopora sp., Cloncetes granulifera, Rhombopora sp., and Marginifera sp.	0.6
Towle shale. (33.5 feet exposed)	
Unnamed shale member. (11.2 feet)	
Shale, clayey, noncalcareous; gray to blue-gray; thin-bedded; thin coal lens near base, numerous carbon stains on bedding planes in lower part, iron and limonite stains.	11.2
Indian Cave sandstone member. (21.3 feet exposed)	
Sandstone, shaly in upper part; fine, well-sorted quartz grains; tan to tan-brown; thin-bedded with some crossbedding; mica flakes numerous, limonite stains and concretions, few carbon stains.	21.3
Covered interval.	11.0
French Creek shale. (5.5 feet exposed)	
Shale, clayey, noncalcareous; gray-brown, weathers yellow-tan; thin-bedded to blocky; numerous limonite stains.	5.5
Jim Creek limestone. (1.1 feet)	
Limestone, hard, dense; gray with a purplish tint, weathers gray with a brown zone near the top; massive, weathers to form blocks which weather further into small chips; iron stained in upper part. Crinoid columnals, Cloncetes granulifera, Rhombopora sp., Dictyoclostus americanus, Aviculopinna sp., and Composita sp.	1.1
Friedrich shale. (12.3 feet)	
Shale, clayey, noncalcareous; gray-green at base becoming tan-gray in upper part, weathers yellowish-tan; thin-bedded; limonite-stained.	8.2
Covered interval.	4.1

Grandhaven limestone. (1.6 feet)

Limestone, hard; gray with a green tint, weathers tan-gray; massive, weathers to form irregular blocks or small chips; iron stains. Crinoid columnals abundant, small and large fusulinids, echinoid spines, and Allorisma sp. 1.6

Dry shale. (9.8 feet exposed)

Shale, silty, very calcareous; gray-green, weathers tan; thin-bedded; thin limestone lens near base. Chonetes granulifera, Rhombopora sp., crinoid columnals, Derbyia sp., Fleurophorus sp., and Aviculopecten occidentalis. This shale is possibly a transitional phase between the Dry shale and the Grandhaven limestone. 2.1

Shale, clayey, noncalcareous; gray-green weathers light gray-green; thin-bedded; numerous calcareous nodules at base; some limonite stains. 3.6

Shale, silty, calcareous; tan-brown, weathers yellow-brown; thin-bedded; iron stains and calcareous nodules. 4.3

Base covered.

Section 9

This section from the top of the Aspinwall limestone to the French Creek shale, inclusive, was measured in a small stream bank in the NW¼ NW¼ sec. 31, T. 10 S., R. 9 E.

	Feet
Black, silty; limestone fragments.	2 ±
Aspinwall limestone.	
Limestone, hard, brecciated, somewhat crystalline, gray-orange weathers gray, massive, weathers blocky; limonite stains and nodules abundant; clay balls and lenses, limonite zone at base; crinoid columnals abundant, Bellerophon sp., Pleurophorus sp.	1.1
Towle shale.	
Shale, clayey, calcareous; tan-gray weathers tan; thin-bedded; contains calcareous nodules. Calcareous zone in middle, some limonite stains on bedding planes.	6.9
Brownville limestone. (1.9 feet)	
Limestone, soft; argillaceous gray-green to tan weathers gray; blocky, weathers nodular; heavily limonite-stained; Cleonetes granulifera abundant, Marginifera sp., common, crinoid columnals abundant, Rhombopora sp., Lissoclonetes geinitzianus and Fenestella sp.	1.9
Pony Creek shale. (6.9 feet)	
Shale, (mostly covered) silty, calcareous; tan, weathers tan; thin-bedded; heavily limonite-stained.	6.9
Caneyville limestone. (3.8 feet)	
Limestone, hard; tan-brown weathers tan-gray; massive, weathers blocky; limonite nodules and stains abundant, clay balls incorporated. Fossil fragments abundant.	0.5
Shale, clayey, calcareous; gray, weathers tan-gray; thin-bedded; calcareous zone present at base. Another calcareous zone occurs 4 ft. from base (zone is .5 ft. thick), on top of which is a thin, carbonaceous lens containing wood fragments. Limonite stains occur on bedding planes. Limonite nodules and concretions are present on weathered surface with some minute mica flakes. Derbyia crassa and D. cymbula are abundant in the calcareous zones, the rest of the shale is non-fossiliferous.	9.6

French Creek shale. (20.0 feet exposed)

Shale, silty to clayey, noncalcareous; slightly arenaceous in center part; gray to tan-gray weathers tan; thin-bedded to blocky; limonite stains on bedding and fracture planes, limonite nodules and plates appear on weathered surface, carbon stains in places. 19.1

Base covered.

Section 10

This section from the base of the Five Point limestone to the Pony Creek shale, inclusive, is exposed in a ditch along a road in the NE¼ SE¼ sec. 7, T. 11 S., R. 9 E.

	Feet
Base of Five Point limestone	
West Branch shale. (19.6 feet)	
Shale, clayey, calcareous; gray, weathers tan-gray; thin-bedded; numerous limonite plates, limonite stains on bedding planes.	5.5
Limestone, hard; gray-brown, weathers tan; massive, weathers to small blocks; lenticular. Fossil fragments of Derbyia sp., Composita sp., Rhombopora sp., echinoid spines, crinoid columnals, Ambocoelia sp., and others very abundant.	0.1
Shale, clayey, with some silt, slightly arenaceous, calcareous; gray; thin-bedded; limonite-stained.	7.1
Shale and two thin limestones, arenaceous; tan-brown; thin-bedded; mica flakes present; heavily limonite stained. Neuropteris sp., and wood fragments.	0.9
Shale, clayey, calcareous, arenaceous; blue-gray, weathers blue-gray to tan; thin-bedded; iron stains on fracture planes.	.8
Shale, silty, calcareous, arenaceous; tan-brown; thin-bedded; heavily limonite-stained, numerous limonite places. Neuropteris sp., and wood fragments.	1.6
Shale, clayey, calcareous; blue-gray; thin-bedded.	3.5
Falls City limestone. (2.8 feet)	
Limestone, hard; gray-brown, weathers tan-brown; massive, weathers to thin blocks, weathering exposes thin bedding planes; limonite-stained. Rhombopora sp.	.2
Limestone, soft; gray-brown weathers tan; porous with fibrous appearance, cavernous; limonited-stained.	2.6
Hawxby shale. (27.6 feet)	
Shale, clayey, slightly calcareous; gray-green; thin-bedded; limonite stains on bedding planes.	4.9
Limestone, hard, argillaceous; gray to gray-brown, weathers tan-gray; massive weathers in blocks; limonite stains present. Pleuroptorus albequus, Yoldia sp., Fenestella sp., Derbyia crassa, Edmondia sp., Myalina sp., Aviculopecten occidentalis, numerous fossil fragments.	.35
Shale, clayey, slightly calcareous; gray-green; thin-bedded; iron stains on bedding planes, few calcareous nodules present.	2.4

Limestone, hard, dense, somewhat argillaceous; blue-gray to tan, weathers tan; massive, weathers in irregular blocks; iron stains on fracture planes; Worthenia sp., Hyalina sp., Euomphalus sp., abundant, Aviculopecten occidentalis, Pleurophorus albequus abundant, and Pseudozaptia tawni. 0.4

Shale, clayey with some silt, noncalcareous; gray, weathers tan-gray; thin-bedded; limonite stains. . . 5.5

Limestone, hard, argillaceous; tan, weathers tan; massive, weathers nodular; iron stains Pleurophorus albequus, Euomphalus sp., and few fossil fragments. . .4

Shale, clayey, noncalcareous; tan-gray, weathers tan; thin-bedded; iron-stained. 1.4

Limestone, hard, gray-brown; massive, weathers to small blocks; iron-stained. Lozonema sp., Pleurophorus albequus sp., Bellerophon sp., and Loxonema sp. 1

Shale, clayey, noncalcareous; blue-gray weathers tan; thin-bedded; limonite stains. 1.4

Limestone, hard, dense; gray-brown, weathers tan; massive; iron stains on fracture planes. Bellerophon sp., Pleurophorus albequus abundant, and Hyalina sp. . . .15

Limestone, hard, crystalline; gray to brown, weathers tan; massive, weathers blocky; limonite nodules and clay balls in upper part, Bellerophon sp., Pleurophorus albequus, Hyalina sp., Aviculopecten occidentalis, and Euomphalus sp. 3

Shale, clayey, noncalcareous; tan to tan-gray weathers tan; thin-bedded; limonite stains. 6.5

Limestone, soft; tan; porous, cavernous, gives fibrous appearance; heavily limonite stained. 2.1

Shale, clayey, noncalcareous; tan; thin-bedded; limonite stains on bedding planes. 1.7

Aspinwall limestone. (0.3 feet)

Limestone, hard; gray-brown with a greenish tint, weathers tan; massive, weathers blocky; septarian-like appearance on top; limonite stains and iron specks present. 3

Towle shale. (7.1 feet)

Shale, silty with some clay, calcareous, gray-green, weathers tan; few calcareous nodules and limonite stains. 7.1

Brownville limestone. (0.7 feet)

Limestone, hard, argillaceous, crystalline in part; gray-brown with green tint in places weathers light gray; massive weathers blocky; lenticular, some limonite specks are present. 7

Pony Creek shale (8.5 feet exposed)

Shale, clayey, somewhat silty, calcareous, blue-gray, weathers tan; thin-bedded; iron stains present. . . 8.5

Base covered.

Section 11

This section from the Falls City limestone to the Dawxby shale, inclusive, was measured in a road cut in the SW¼ SE¼ NE¼ sec. 9, T. 11 S., R. 2 E.

	Feet
Soil; gray-brown.	2 ±
Falls City limestone. (4.1 feet exposed)	
Limestone with thin shale partings, soft; tan-brown, weathers tan; porous, cavernous, weathering produces thin-bedded appearance, portions have a fibrous appearing texture, weathers nodular. Juresania nebrascensis, Pleuroplorus albequus common in basal part.	4.1
Dawxby shale. (21.35 feet exposed)	
Shale, clayey, slightly calcareous; gray to tan weathers tan; thin-bedded, thin siltstone-like plates appear on weathered surface; limonite stain.	3.5
Limestone, argillaceous, slightly crystalline; gray-brown weathers tan; nodular with a thin platy limestone on top; iron stains on fracture planes. Aviculopecten occidentalis, Pleuroplorus albequus, Yoldia sp., small fossil fragments very abundant in upper part.	0.8
Shale, clayey, slightly calcareous; gray-brown, weathers tan; thin-bedded.	1.7
Limestone, hard, dense, argillaceous; gray-brown, weathers tan to gray; massive, weathers blocky. Pleuroplorus albequus very abundant, some are quite long (0.15 feet). Euomphalus pernodosus, Hyalina sp., and Aviculopecten occidentalis.	.2
Shale, clayey, noncalcareous; gray to brown, weathers tan; thin-bedded; limonite stains.	4.1
Limestone, hard, somewhat crystalline, argillaceous in upper part; gray-brown, weathers tan; massive, weathers in rounded blocks. Hyalina subquadrata, Hyalina sp., Euomphalus pernodosus, Pleuroplorus albequus, fossil fragments very abundant.	.9
Shale, clayey, calcareous; blue-gray, weathers tan-gray; thin-bedded to blocky; small limestone lens 2.5 feet from the base. The limestone lens contains the following fossils: Pleuroplorus albequus, Pelleropton sp., Euomphalus pernodosus, Hyalina sp., and Worthenia sp. The shale is nonfossiliferous.	5.3
Limestone, hard, crystalline; dark gray, weathers tan; massive, weathers in irregular blocks; iron-stained. Pelleropton sp. abundant, Pleuroplorus albequus abundant, Aviculopecten occidentalis, Hyalina sp., Euomphalus pernodosus. Fossils compose the bulk of this limestone.	.35

Shale, clayey, calcareous; tan to gray, weathers tan to gray, weathers tan-gray; thin-bedded to blocky; some limonite and iron stains on bedding planes. . . 4.0'

Base covered.

Section 12

This section from the base of the Americus limestone to the Hawxby shale, inclusive, was measured in an old trail, on the south side of a hill in the center of the SW¼ sec. 30, T. 10 S., R. 9 E.

	Feet
Americus limestone, only basal part exposed.	
Hamlin shale. (37 feet)	
Covered interval.	31.5
Shale, clayey, calcareous; gray-green weathers, light gray-green; thin-bedded; numerous limonite nodules. .	5.5
Five Point limestone. (3.8 feet)	
Limestone, hard, argillaceous; gray, weathers gray; thin-bedded, weathers blocky; some limonite stains.	2.2
Limestone, hard; gray, weathers gray; massive, weathers blocky; some limonite stains; Marginifera histricula, Pleuroplorus albequus, Ambocoelia sp., Neospirifera sp., echinoid spines, Cloneles granulifera, crinoid columnals, Aviculopecten occidentalis, Dictyoclostus hemiplicatus, Hipidomella carbonaria, Derbyia sp., Rustedia mormoni, Composita ovata, Lissocloneles geinitzianus. Forms hillside bench.	1.6
West Branch shale. (11.1 feet exposed)	
Shale, silty with some clay, calcareous; gray-brown to blue-gray, weathers tan-gray, thin-bedded with a fine grain, thin-bedded sandstone lens containing limonite stains and mica flakes occurs in the middle of this shale; limonite stains and plates are common; wood and leaf fragments occur in the upper part.	11.1
Covered interval.	6.5
Falls City limestone. (0.35 feet exposed)	
Limestone, soft, porous; tan-brown; blocky, shows bedding planes on weathered surface; lenticular; heavily limonite-stained.	0.35
Hawxby shale. (10.2 feet exposed)	
Shale, clayey, noncalcareous; gray-green; thin-bedded to blocky.	8.5
Limestone, soft; gray-brown, weathers brown; massive, weathers in small chips; limonite stains abundant; Polypora sp., Aviculopecten occidentalis abundant, Pleuroplorus albequus abundant, Luomphalus sp., common, Pseudomontis hawni, Promptilus vetulus. . .	.3
Shale, clayey, calcareous; gray-green; thin-bedded; limonite-stained.	.9

Limestone, soft, argillaceous; gray-brown, weathers tan-brown; massive, weathers nodular and blocky; limonite stains abundant; Aviculopecten occidentalis and Pleuroptorus albequus abundant, Worthenia sp., Hyalina sp., Polypora sp., Luperalus sp. 2

Shale, clayey with some silt, calcareous; gray-green, weathers tan-brown; thin-bedded; limonite stains common. 3

Limestone, soft, gray-brown, weathers brown; massive, weathers blocky and irregular; limonite stains common; Pleuroptorus albequus, Hyalina sp., Aviculopectan occidentalis. 6

Base covered.

Section 13

This section from the Americus limestone member of the Foraker limestone to the Pamlin shale, inclusive, is exposed in a stream cut in the NE¼ NW¼ sec. 20, T. 10 S., R. 9 E.

	Feet
Colluvium.	5 +
Foraker limestone	
Americus limestone member. (4.1 feet)	
Limestone, hard, dense; dark gray, weathers tan-gray; massive, weathers blocky, with somewhat shaly appearance. Marginifera sp., Derbyia crassa, Amboceolia sp., crinoid columnals, echinoid spines, and fusulinids. .	0.95
Shales, clayey, noncalcareous; black becoming tan-gray at base, weathers gray; thin-bedded to fissile; calcareous zone in upper part.	2.1
Limestone, hard, dense; dark gray, weathers tan-gray; massive, weathers blocky to shaly. Pelleroplon sp., fusulinids, Aviculopecten occidentalis, crinoid columnals, Aviculopinna peracuta, Hyalina sp., Euomphalus sp.	1.1
Pamlin shale. (13.9 feet exposed)	
Shale, silty, calcareous; gray; blocky; calcium carbonate stains in upper part.	1.2
Shale, silty, calcareous; gray-green; blocky; calcareous lenses in middle and upper parts; iron stains on fracture planes.	7.6
Shale, silty, with some clay, calcareous; light gray-green weathers light gray; blocky; calcareous lens near base; iron stains abundant on fracture planes. .	5.1
Base covered.	

Section 14

This section from the base of the Howe limestone member of the Red Eagle limestone to the Hamlin shale, inclusive, is exposed in a railroad and road cut in the [illegible] sec. 7, T. 10 S., R. 6 E.

	Feet
Red Eagle limestone	
Base of the Howe limestone member.	
Bennett shale member. (3.2 feet)	
Shale, clayey, slightly silty, slightly calcareous; olive drab, weathers tan; thin-bedded. Brachiopod fragments.	2.0
Shale, silty, carbonaceous, calcareous; black, weathers gray; thin-bedded. Composita ovata, Aviculopinna peracuta, Amboccelia planoconvexa, Derbyia crassa, and Aviculopecten occidentalis.	0.5
Shale, silty, calcareous, carbonaceous; black, weathers blue-gray; thin-bedded.	1.2
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded. Composita ovata, Marginifera wabashensis, Rustella moreni, Hustedia mormoni, Hesgoclonotes geinitzianus, and Dictyoclostus sp.	1.05
Glenrock limestone member. (1.45 feet)	
Limestone, hard, dense; gray-brown, weathers tan; massive, weathers blocky; some small clay nodules. Fusulinids, and few brachiopod fragments.	1.45
Johnson shale. (24.0 feet)	
Shale, clayey, with some silt, slightly calcareous, carbonaceous in lower part; olive-drab, grading downward to black; thin-bedded to blocky in upper part, thin-bedded in lower part.	3.2
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded.	0.8
Shale, clayey, with some silt, slightly calcareous; olive drab, weathers tan; thin-bedded; carbon-stained.	1.75
Limestone, medium hard, argillaceous; tan-gray, weathers tan; massive to platy in lower part, platy in upper part; lenticular.	1.0
Shale, silty, calcareous; olive drab, weathers light gray; thin-bedded; two thin calcareous lenses in the middle; limonite-stained.	1.9
Limestone, argillaceous; tan-gray; massive to platy; lenticular.	0.9
Shale, clayey with some silt, calcareous; olive drab, weathers tan; thin-bedded to blocky; limonite-stained.	0.6

Shale, silty, slightly calcareous; yellow-green, weathers tan; thin-bedded; lenticular. 0.1
Shale, silty, calcareous; olive drab in upper part, grading downward to gray-green, weathers gray; thin-bedded to blocky. 2.0
Shale, silty, calcareous; gray, weathers light gray; blocky, massive in upper part; lenticular. 3.6
Limestone, medium hard, argillaceous; gray; massive, weathers blocky to platy; thin shale parting near the top, limonite stained. 2.35
Shale, clayey, calcareous; gray-green, weathers light gray; thin-bedded. 8.3

Foraker limestone. (51.4 feet)
Long Creek limestone member. (9.0 feet)
Limestone, soft, fine-grained; gray-orange, weathers tan; massive, weathers platy and irregularly; calcite nodules in bedding planes. 5
Limestone, soft, fine-grained; gray-orange, weathers tan; massive; porous, celestite nodules. 2
Limestone, soft dolomitic; tan-gray, weathers light tan; massive; contains some celestite nodules. 5
Shale, silty, slightly calcareous; olive drab, weathers gray; blocky; carbon stains on bedding planes. 5
Shale, clayey with some silt, slightly calcareous; gray-orange, weathers tan; blocky. 35
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded. 1
Limestone, soft; gray-orange, weathers tan; massive in lower part, platy in upper part. 2.6
Limestone, soft, argillaceous, dolomitic; dark tan, weathers light tan; massive; contains small celestite nodules. 2.4
Limestone, soft, dolomitic; tan-brown; blocky; lenticular; limonite-stained. 15

Hughes Creek shale member. (38.9 feet)
Shale, silty, noncalcareous; olive drab, with tan streaks, weathers tan; blocky. 5
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded to blocky. 85
Shale, silty, very calcareous; gray, weathers tan; thin-bedded, lenticular. Orbiculoidea sp., and organic material. 2
Shale, silty, calcareous; blue-gray to olive drab, weathers tan; thin-bedded to blocky; lenticular. . . .8
Limestone, argillaceous; gray-orange, weathers tan; massive; lenticular. Fusulinids very abundant. 1.3
Shale, silty, very calcareous; gray, weathers light gray; thin-bedded. Fusulinids very abundant, crinoid columnals. 1.9
Shale, clayey, noncalcareous; dark gray to black, weathers gray; fissile. Fusulinids and crinoid columnals at very base. 4.2

Shale, silty, very calcareous; gray; thin-bedded to blocky; fusulinids abundant. Crinoid columnals, Neospirifera sp., Ambocoelia planoconvexa. Core resistant to weathering than adjacent shales. . . . 0.8
Shale, clay with some silt, calcareous; gray-green, weathers gray; thin-bedded. 2
Shale, silty, calcareous; gray-brown, weathers gray-orange; thin-bedded; lenticular; limonite-stained. . .15
Shale, silty, calcareous; gray, weathers tan-gray; thin-bedded to blocky. Allorisma terminale, Ambocoelia planoconvexa, Rhipidomella carbonaria, echinoid spines, crinoid columnals, fusulinids, Composita ovata, and Marginifera sp. 1.3
Shale, carbonaceous, noncalcareous; black, weathers blue-gray; thin-bedded; occasional clay inclusion, some limonite-stained zones. Orbiculoidea missouriensis, Ambocoelia planoconvex, and Chonetes granulifera. 1.4
Shale, silty, calcareous; gray-orange to gray, weathers gray-orange; thin-bedded; some limonite stains. Orbiculoidea missouriensis abundant. 15
Limestone, hard; tan, weathers tan-gray; massive, Algae, brachiopod fragments, and fusulinids. 1.2
Shale, clay in upper part grading downward to silt, calcareous; dark gray grading downward to gray-orange, weathers tan to gray; thin-bedded to fissile. Dictyoclostus americanus, Derbyia crassa, and Marginifera sp. 8.35
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded to blocky; calcareous nodules in upper part. Large crinoid columnals. Derbyia sp. 2.2
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded. Ambocoelia planoconvexa, Derbyia sp., crinoid columnals and fusulinids. 8
Limestone, argillaceous; gray; massive, weathers with a shaly appearance; lenticular. Ambocoelia planoconvexa and Lissochonetes geinitzianus. 3
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded. Ambocoelia sp. 2
Limestone, argillaceous; gray; massive, weathers with a shaly appearance; lenticular. Wellerella sp., crinoid columnals, Rhipidomella carbonaria, Dictyoclostus sp., Derbyia crassa, and Neospirifera sp. . .5
Shale, silty, slightly calcareous; olive drab, weathers gray; thin-bedded. Derbyia deercreekensis, Neospirifera triplicatus, Rhombopora sp., crinoid columnals, Ambocoelia planoconvexa, Polypora sp., and Lingula carbonaria. 65
Limestone, argillaceous; dark gray, weathers gray-orange; thin-bedded. 15
Shale, silty, calcareous; gray, weathers light gray; thin-bedded. Ambocoelia sp., and Marginifera hystricula. 1

Limestone, hard; tan-gray; massive. Some brachiopod fragments. 0.8
Shale, silty, calcareous; gray; blocky; limonite-stained in lower part. Dictyoclostus americanus, Derbyia crassa, Echinoconchus sp., Linoproductus sp., Ambocoelia planoconvexa, and Marginifera sp. . .5
Shale, clayey, slightly calcareous; dark gray to black, weathers gray; blocky to thin-bedded. Dictyoclostus sp., and Derbyia crassa. 1.5
Limestone, argillaceous; gray-orange; blocky. Dictyoclostus americanus, Rustella mormoni, Neospirifera sp., Ambocoelia planoconvexa, and Derbyia crassa. 1.3
Shale, silty, calcareous in upper part; gray grading downward to black, weathers gray; thin-bedded to fissile. Composita subtilita, Dictyoclostus americanus, D. portlocklanus, fusulinids, Chonetes granulifera, Marginifera sp., Echinoconchus sp., Linoproductus magnispinus, Juresania nebrascensis, Ambocoelia planoconvexa, Derbyia crassa, Orbiculoidea missouriensis, and Aviculopecten occidentalis. . . . 9.2
Shale, silty, very calcareous; gray-brown, weathers gray; thin-bedded; lenticular, limonite-stained. . . .3
Shale, silty, calcareous; dark gray, weathers gray with orange spots; thin-bedded. Crinoid columnals, Dictyoclostus americanus, Composita subtilita, and Chonetes granulifera. 3

Americus limestone member. (3.95 feet)
Limestone, hard, slightly crystalline; blue-gray, weathers tan; massive. Large crinoid columnals, echinoid spines, brachiopod fragments. Wellerella tetrahedra, Stenopora sp., and fusulinids. 1.0
Shale, slightly silty, calcareous; black, weathers gray; thin-bedded. 2
Shale, silty, calcareous; gray, weathers light gray; thin-bedded. 55
Shale, silty, noncalcareous; dark gray, weathers light gray; thin-bedded to fissile; carbon stains on bedding planes. 1.0
Limestone, dense, hard, argillaceous in the lower part; dark gray, weathers tan-gray; massive. Algae abundant in the lower part. Crinoid columnals and brachiopod fragments. 8

Hamlin shale. (3.8 feet exposed)
Shale, silty, calcareous; red-brown, weathers tan-gray; thin-bedded. Some algae. 1
Limestone, arenaceous; gray-orange, weathers tan; massive; lenticular. 3
Shale, clayey, calcareous; gray-orange, weathers tan; thin-bedded to blocky. 35
Shale, silty, calcareous; dark gray, weathers light gray; blocky; limonite stains in upper part. 1.55
Shale, clayey with some silt, calcareous; dark gray, weathers light gray; thin-bedded. 2.9

Base covered.

Section 13

This section from the base of the Burr limestone member of the Grenola limestone to the Hughes Creek shale member of the Foraker limestone, inclusive, is exposed in a railroad cut in the NW¼ SW¼ NE¼ sec. 24, T. 10 S., R. 7 E.

	Feet
Colluvium.	5 ±
Grenola limestone. (0.8 feet exposed)	
Burr limestone member. (0.8 feet exposed)	
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky and irregular. Crinoid columnals, echinoid spines and brachiopod fragments.	0.8
Roca shale. (23.6 feet)	
Shale, clayey, calcareous; tan-gray; thin-bedded; calcium carbonate and limonite-stained.	4.1
Limestone, hard, dense, somewhat argillaceous; gray, weathers tan-gray; massive, weathers blocky and platy at top; iron stains on fracture planes. Small crinoid columnals abundant.	1.0
Shale, silty, noncalcareous; green, weathers gray-green; thin-bedded to blocky; iron stains on fracture planes.	3.3
Shale, silty, calcareous; tan, weathers light gray; thin-bedded; iron stains on bedding planes.	.7
Shale, silty, slightly calcareous; green, weathers gray-green; thin-bedded to blocky; limonite stains on fracture planes.	3.1
Shale, clayey with some silt, calcareous; purple, weathers light purple; thin-bedded.	1.8
Shale, silty with some clay, calcareous; gray, weathers tan-gray; thin-bedded; iron stains on bedding planes, calcareous nodules.	.9
Shale, silty, calcareous; maroon; thin-bedded.	1.8
Shale, clayey with some silt, calcareous; green, weathers light green; thin-bedded.	.8
Limestone, soft, argillaceous; gray-green, weathers gray; massive to blocky, weathers blocky; iron stains on fracture planes.	.4
Shale, clayey with some silt, calcareous; green, weathers light green; blocky.	.3
Shale, clayey with some silt, calcareous; maroon grading down into gray-maroon and purple, weathers maroon to gray; thin-bedded to blocky; iron stains on bedding planes.	3.7
Shale, clayey with some silt, slightly calcareous; light green to green, weathers gray-green; thin-bedded; iron stains on bedding planes.	1.4

Red Eagle limestone. (10.8 feet)
Lowe limestone member. (4.3 feet)
Limestone, soft; tan, weathers tan-gray with some maroon stains; massive, weathers porous and irregular; limonite-stained. Ostracods abundant, Neospirifera sp., and Aviculopinna peracuta. 4.3

Bennett shale member. (4.9 feet)
Shale, silty with some clay, calcareous; dark gray to black, weathers dark gray; thin-bedded to fissile; calcareous zone near middle. Composita sp., Derbyia crassa, Juresania nebrascensis, Marginifera hystricula, Dictyoclostus americanus, Orbiculoidea missouriensis, Ambocoelia planoconvexa, Rustella mormoni. 4.9

Glenrock limestone member. (1.6 feet)
Limestone, hard; tan-gray; massive, weathers blocky; some limonite and maroon stains. Ambocoelia sp., fusulinids abundant, Euomphalus sp., Pelleroncon sp., and numerous fossil fragments. 1.6

Johnson shale. (21.0 feet)
Shale, clayey, calcareous; olive drab to dark gray, weathers tan-gray; thin-bedded. 2.1
Shale, silty, calcareous; tan-gray with some dark gray lenses; thin-bedded to blocky; has high content of calcium carbonate; iron stains on fracture planes. Shale more resistant to weathering in the basal part. 5.4
Shale, silty, calcareous; tan, weathers tan-yellow; thin-bedded to blocky and has a nodular appearance; limonite-stained. 0.8
Shale, silty, slightly calcareous; light to dark gray with a green tint, weathers gray; blocky; few iron stains on fracture planes. 2
Shale, silty, slightly calcareous; dark green, weathers light green; thin-bedded. 3
Shale, silty, slightly calcareous; dark green, weathers gray-green; blocky; limonite-stained. 5
Shale, silty, calcareous; gray, weathers light gray; thin-bedded to blocky; iron stains on fracture planes. .8
Shale, silty, very calcareous; tan-gray, weathers light gray; blocky, has a columnar appearance; lenticular; iron stains on fracture planes. 8
Shale, silty, slightly calcareous; dark green, weathers green; blocky; limonite stains on fracture planes. . 1.0
Shale, silty, very calcareous; gray; blocky with suggestion of columnar appearance; few iron stains. . . .8
Shale, silty, slightly calcareous; green to olive drab, weathers gray with a green tint; blocky; limonite stains on fracture planes.. . . . . 1.7
Limestone, soft, dense, argillaceous; gray, weathers tan-gray; blocky, weathers irregular and blocky; iron stains. 9

Shale, silty with some clay, calcareous; olive drab to gray-green, weathers gray; blocky to thin-bedded; limonite stains abundant in upper portion. 4.8

Foraker limestone
Long Creek limestone member. (8.5 feet)
Limestone, soft, lightly dolomitic; gray-orange, weathers tan-gray; massive, weathers in irregular blocks and plates; iron stains abundant on fracture planes. . . 8.5

Hughes Creek shale member. (4.5 feet exposed)
Shale, silty, calcareous; tan to blue-gray; thin-bedded to blocky; some limonite stains. 1.7
Limestone, soft, argillaceous; tan-gray, weathers tan; massive, weathers platy in the top part; lenticular; some iron stains on fracture planes. Crinoid columnals, Pleurophorus sp., Polypora sp., and fossil fragments. .4
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; limonite-stained. Rhombopora sp., Pleurophorus sp., Chonetes granulifera, and numerous fossil fragments. 4
Limestone, soft; tan-gray; massive weathers irregular. Fusulinids very abundant, crinoid columnals, and Chonetes granulifera. 2.0

Base covered.

Section 16

This section from the Burr limestone member of the Grenola limestone to the base of the Howe limestone member of the Red Eagle limestone, inclusive, is exposed in a road cut in the NW¼ SE¼ sec. 7, T. 10 S., R. 8 E.

	Feet
Silt, gray-brown.	2 ±
Grenola limestone. (12.5 feet exposed)	
Burr limestone member. (12.5 feet exposed)	
Limestone, soft; grey-orange, weathers tan; platy; lenticular.	0.2
Limestone, soft; gray, weathers tan; massive; cavernous at base; lenticular.	.3
Limestone, dense; gray-orange, weathers tan; massive, weathers platy at base.	.8
Shale, clayey, slightly calcareous; olive drab, weathers tan; thin-bedded to blocky; iron-stained.	3.2
Limestone, soft; red-brown, weathers tan; massive; porous and lenticular. Ostracods very abundant. . . .	.25
Limestone, hard, dense; gray-orange, weathers tan; massive. Some brachiopod fragments.	1.8
Limestone, hard, dense; light gray, weathers tan; massive. Echinoid spines.	2.1
Limestone, slightly crystalline; gray, weathers tan; massive. Brachiopod fragments and some algae. . . .	.2
Shale, clayey, noncalcareous; gray grading downward to black; weathers gray; fissile; some carbon stains. .	1.25
Limestone, hard, dense; tan; massive, weathers blocky. Crinoid columnals, Chonetes granulifera, Hyalina subquadratus, and brachiopod fragments.	2.4
Roca shale. (23.45 feet)	
Shale, silty, calcareous; dark gray with light gray bands, weathers light gray; thin-bedded. Worm burrows? abundant.	.2
Limestone, hard, dense; gray-brown, weathers tan; massive; lenticular. Worm burrows?	.1
Shale, silty, calcareous; dark gray, weathers light gray; thin-bedded; lenticular.	.5
Limestone, argillaceous; grey, weathers light gray; blocky; lenticular.	.3
Shale, silty, calcareous; dark gray, weathers light gray; blocky to fissile.	.35
Shale, clayey with some silty, calcareous; white, mottled with dark gray-green, weathers tan; blocky.	.65
Shale, clayey with some silt, calcareous; dark gray, weathers gray with light grey bands; blocky.	1.05
Shale, clayey, noncalcareous; tan banded with gray, weathers tan; thin-bedded to blocky.	.7
Limestone, hard; tan; massive. Fragments tentatively identified as fossil plants.	1.05

Shale, clayey, with some silt, noncalcareous; light green in the upper part grading downward to a dark green, weathers light green; blocky; iron-stained. . 3.2
Shale, silty, very calcareous; light cream; blocky; heavily iron-stained. 0.9
Shale, clayey with some silt, calcareous; gray-green, weathers light green; blocky; iron stains and clay nodules. 1.9
Shale, silty, noncalcareous; purple in upper part grading downward to maroon, which grades downward to gray; blocky; iron stains on the fracture planes. . 2.6
Shale, silty, noncalcareous; dark grey, weathers gray; blocky; lenticular; limonite stains on bedding planes. .45
Shale, silty, very calcareous; maroon mottled with light gray; blocky. 1.05
Shale, silty, calcareous; maroon mottled with green; blocky. 95
Shale, clayey, noncalcareous; gray-green, weathers light gray; blocky. 5
Limestone, argillaceous; light gray; massive; lenticular. .5
Shale, silty, calcareous; light green; banded with various shades of green; thin-bedded. 4
Shale, clayey with some silt, slightly calcareous; maroon; thin-bedded to blocky; some penecontemporaneous folding. 1.65
Shale, silty, noncalcareous; light green; blocky. . . 1.05
Shale, clayey, slightly calcareous; light gray; thin-bedded to blocky; limonite stains on bedding planes. .15
Shale, silty, calcareous; dark gray, weathers gray; thin-bedded; lenticular. 15
Shale, silty, slightly calcareous; light gray banded with various shades of gray; thin-bedded; limonite stains on fracture planes. 3
Shale, clayey with some silt, noncalcareous; gray, weathers light gray; blocky. 2
Shale, clayey with some silt, noncalcareous; gray-green, banded with various shades of gray, weathers gray; iron-stained. 35
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; blocky. 35
Shale, silty, calcareous; gray; blocky; lenticular. . .3
Shale, clayey with some silt, slightly calcareous; gray to gray-green, weathers gray; blocky; lenticular. . .4
Shale, silty, calcareous; gray-green, weathers gray; blocky; lenticular; limonite stains in basal part. . .7

Red Eagle limestone. (4.45 feet exposed)
Howe limestone member. (4.45 feet)
Limestone, soft; tan, weathers tan-gray; massive; lenticular. 8
Limestone, soft; gray-orange, weathers tan; massive; limonite-stained and maroon stains. 3.65

Base covered.

Section 17

This section from the Cottonwood limestone member of the Beattie limestone to the Nova limestone member of the Grenola limestone, inclusive, is exposed in a road cut in the [illegible] sec. 10, T. 10 S., R. 7 E.

	Feet
Soil, silty; dark gray; some gravel.	1 +
Beattie limestone. (5.1 feet exposed)	
Cottonwood limestone member. (5.1 feet exposed)	
Limestone, hard; gray-orange; massive, weathers to a shaly appearance. Composita sp., and brachiopod fragments.	0.4
Limestone, hard, dense; light gray, weathers tan; massive, weathers blocky; chert nodules in the middle. Fusulinids abundant. Neospirifera sp., echinoid spines, crinoid columnals, Composita sp., Straparolus sp. Forms prominent hillside bench. . .	4.7
Eskridge shale. (35.6 feet)	
Shale, silty, noncalcareous; light green to tan; thin-bedded to blocky; iron stains, maroon stains at the base, calcareous nodules.	2.75
Shale, silty, very calcareous; white; thin-bedded; lenticular.	.3
Shale, clayey, noncalcareous; olive drab, weathers light gray; blocky.	1.2
Shale, silty, calcareous; light gray to gray with violet stains; thin-bedded to blocky; calcareous lens near the top.	1.2
Shale, clayey with some silt, calcareous; maroon; thin-bedded to blocky.	2.05
Shale, clayey with some silt, calcareous; light gray; thin-bedded.	.75
Shale, silty, very calcareous; gray, weathers light gray; blocky; iron-stained.	.5
Shale, clayey, calcareous; maroon mottled with green; blocky.	2.95
Shale, clayey with some silty, calcareous; gray mottled with maroon; thin-bedded to blocky.	1.05
Shale, clayey, calcareous; gray, weathers light gray; thin-bedded.	.55
Limestone, somewhat argillaceous; light gray; massive, weathers blocky; lenticular.	.65
Shale, clayey with some silt, calcareous; dark gray, weathers light gray; thin-bedded to blocky; some calcareous lenses.	2.75
Limestone, argillaceous; dark gray, weathers light gray; massive, weathers blocky; thin shale parting; limonite-stained.	.3

Shale, clayey with some silt, calcareous; gray with light gray streaks; thin-bedded to blocky. 2.2
Limestone, argillaceous; gray, weathers light gray; massive, weathers blocky; lenticular; limonite stains on weathered surface. Aviculopecten occidentalis, Hyalina sp. 1.5
Shale, silty, calcareous; gray-brown, weathers tan; thin-bedded; thin calcareous lens near top. 1.45
Shale, silty, calcareous; gray-green, weathers light green; blocky. 1.0
Shale, silty, calcareous; maroon; blocky. 0.8
Shale, silty, calcareous; gray-green mottled with some maroon, weathers light green; blocky. 2
Shale, clayey, calcareous; dark maroon; blocky; some limonite stains. 1.65
Shale, silty, slightly calcareous; dark purple to maroon mottled with green and gray; blocky; columnar structure. 5.8
Shale, clayey with some silt, calcareous; dark green mottled with purple; thin-bedded to blocky. 85
Shale, silty, calcareous; gray; thin-bedded to blocky. .4
Shale, silty, calcareous; gray-green, weathers light green; thin-bedded; calcareous lens in lower part. . 1.25

Grenola limestone. (3.9 feet exposed)
Neva limestone member. (3.9 feet exposed)
Limestone, hard, dense; tan-gray; massive weathers blocky; conchoidal fracture. Composita sp., Anbocoelia sp., crinoid columnals, echinoid spines, and Meekella striatocostata. 1.5
Shale, silty, calcareous; dark gray, weathers light gray; thin-bedded; very lenticular. Crinoid columnals, Composita sp., Anbocoelia sp., and echinoid spines. 5
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; crinoid columnals, echinoid spines, and brachiopod fragments. 1.9

Base covered.

Section 18

This section from the Florena shale member of the Pesttie limestone to the top of the Burr limestone member of the Grenola limestone, inclusive, is exposed in an old road cut in the NE¼ NE¼ sec. 28, T. 10 S., R. 7 E.

	Feet
Pesttie limestone. (14.5 feet exposed)	
Florena shale member. (8 feet)	
Shale, silty, calcareous; tan to gray, weathers tan-gray; thin-bedded; some calcareous plates in the lower part. Chonetes granulifera very abundant. Meekella striatocostata, Polypora sp., Rhombopora sp., Fenestella sp., Composita ovata, Stenopora sp., Fistulipora sp., crinoid columnals, echinoid spines, and trilobites.	8.0
Cottonwood limestone member. (6.5 feet)	
Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocky; lens of chert nodules in middle with chert nodules scattered throughout. Fusulinids very abundant in upper half, crinoid columnals, echinoid spines, Polypora sp., Composita sp., brachiopod fragments, corals common near base. Limestone fractures irregularly and where exposed, large blocks are slumped on the face of the underlying shale. Forms prominent hillside bench. Growth of bushes at base is characteristic.	5.9
Limestone, soft; light gray, weathers tan; massive, weathers with a shaly appearance; lenticular. Crinoid columnals.	.15
Limestone, hard; gray-orange, weathers gray; massive; lenticular. Brachiopod fragments.	.45
Eskridge shale. (27.30 feet)	
Shale, clayey, noncalcareous; light green; thin-bedded; calcium carbonate stains and nodules.	2.35
Shale, silty with some clay, very calcareous; light gray; thin-bedded to blocky; small clay nodules; lenticular.	.7
Shale, clayey, noncalcareous; gray, weathers light gray; blocky; lenticular.	.6
Shale, clayey with some silt, very calcareous; light gray to light violet; blocky to thin-bedded.	2.05
Limestone, argillaceous; light gray, weathers tan; massive; oolitic in part. Aviculopecten occidentalis.	.55
Shale, clayey with some silt, calcareous; light green, weather light gray; blocky.	.5
Shale, silty, calcareous; maroon; blocky.	.15

Shale, clayey, calcareous; gray-brown; blocky. 0.3
Shale, clayey, calcareous; maroon; blocky. 4
Shale, clayey with some silt, calcareous; olive drab, weathers tan; blocky. 1.65
Shale, silty, calcareous; gray, mottled with maroon; thin-bedded to blocky. 1.1
Shale, clayey, slightly calcareous; dark gray, weathers light gray; thin-bedded. 5
Shale, silty, calcareous; maroon; blocky to thin-bedded. 2.15
Shale, clayey, calcareous; dark gray in upper part grading downward to tan-gray, weathers tan; thin-bedded. 3.45
Shale, clayey with some silt, calcareous; dark gray-green, weathers light gray-green; blocky. 1.1
Shale, silty, calcareous; maroon mottled with gray and green; thin-bedded to blocky. 2.6
Shale, silty, calcareous; dark violet, weathers light purple; blocky; lenticular. 2.85
Shale, clayey with some silt, calcareous; maroon; blocky; lenticular. 9
Shale, silty, noncalcareous; violet; blocky; lenticular. 1.2
Shale, clayey, slightly silty, calcareous; light gray-green, weathers gray-green; thin-bedded. 5
Shale, clayey with some silt, calcareous; maroon; lenticular. 2
Shale, silty, calcareous; gray-green, weathers light gray; thin-bedded. 6
Shale, clayey with some silt, calcareous; maroon and gray-green; thin-bedded; lenticular. 8
Shale, clayey with some silt, calcareous; gray-green, weathers light gray-green; thin-bedded. 6

Grenola limestone. (25.8 feet measured)
Neva limestone member. (10.2 feet)
Limestone, hard; light gray; massive, weathers platy; shale parting in upper part. Echinoid spines, Polypora sp., and brachiopod fragments. 2.5
Limestone, hard, dense; light gray, weathers tan; massive, weathers blocky. Crinoid columnals, echinoid spines, Composita sp., and brachiopod fragments. Forms hillside bench. 5.5
Shale, silty, very calcareous; light gray; thin-bedded to blocky; lenticular. Lingula carbonaria, Composita ovata, and Orbiculoidea missouriensis. 9
Limestone, hard, dense; gray-orange, weathers tan; massive, weathers blocky; cavernous in lower part. Brachiopod fragments. 3.0
Limestone, soft; tan; massive, weathers blocky; lenticular. 9
Limestone, soft; light gray, weathers tan; massive; lenticular. 6
Shale, clayey, slightly calcareous; dark gray, weathers blue-gray; thin-bedded. Crinoid columnals. 1.5
Limestone, hard; gray-orange, weathers tan; massive, weathers blocky. Echinoid spines, and brachiopod fragments. 1.4

Salem Point shale member. (7.6 feet)

Shale, silty, calcareous; tan with gray stains, weathers light tan; blocky.	0.65
Shale, silty, calcareous; olive drab, weathers light gray; blocky to thin-bedded. Pleurophorus sp. . . .	2.45
Shale, clayey, slightly calcareous; black and gray; weathers gray; thin-bedded.	.5
Limestone, argillaceous; light gray, weathers tan; platy at top becoming massive at base.	.6
Shale, silty, calcareous; light tan; blocky; lenticular.	.25
Shale, silty, calcareous; gray, weathers light gray; thin-bedded.	.8
Shale, silty, calcareous; olive drab, weathers light gray; blocky to thin-bedded.	2.35

Top of Burr limestone member.

Section 19

This section from the Kiss limestone member of the Bader limestone to the Burr limestone member of the Grenola limestone, inclusive, was measured in a road cut in the [illegible] sec. 34, T. 10 S., R. 9 E.

	Feet
Soil, silty; gray-brown.	3 ±
Bader limestone. (4.3 feet exposed)	
Kiss limestone member. (4.3 feet)	
Limestone, hard, argillaceous; tan-gray, weathers tan; massive, weathers blocky to platy. Aviculopecten occidentalis abundant, Pseudomonotis hawni, Hyalina sp., Meekella striatocostata, Derbyia crassa. . . .	0.4
Shales, clayey with some silt, calcareous; tan-gray, weathers tan; thin-bedded to blocky; some limonite stains.	1.1
Limestone, hard; gray, weathers light gray; massive, weathers platy to blocky; slightly porous. Chonetes granulifera, Rhombopora sp., Derbyia sp., Meekella striatocostata, Aviculopecten occidentalis, fusulinids, and Polypora sp.	2.8
Stearns shale. (15.7 feet)	
Shale, silty, calcareous; gray, weathers light gray; thin-bedded to blocky.	2.3
Limestone, very argillaceous; gray, weathers light gray; blocky; few limonite stains.	.3
Shale, silty, calcareous; gray, weathers light gray; blocky.	1.3
Limestone, very argillaceous; gray, weathers light gray; blocky; limonite stains on fracture planes. .	.7
Shale, silty, very calcareous; gray, weathers light gray; thin-bedded to platy; thin calcareous plates on weathered surface.	5.7
Shale, clayey, slightly calcareous; gray-green, weathers tan; thin-bedded to blocky; few calcareous plates, some limonite stains.	1.3
Limestone, soft; gray, weathers tan; cavernous, porous, with a fibery appearance.	.3
Covered interval.	4.8
Beattie limestone. (16.8 feet)	
Morrill limestone member. (3.1 feet)	
Limestone, soft; tan, weathers tan-gray; massive, blocky, porous, weathers irregular; small celestite crystals on weathered surface; algal appearance.	.8
Limestone, hard, dense; gray, weathers tan; massive, weathers irregular; lenticular; some secondary calcite clusters present.	1.2

Limestone, hard, argillaceous; gray-orange, weathers tan, numerous brown specks present; massive, weathers porous, rotten appearance. 1.1

Florena shale member. (7.3 feet)
Shale, silty with some clay, slightly calcareous; tan to gray, weathers tan; thin-bedded to blocky; calcareous nodules and plates present. Fossils present only in the lower 2.4 feet, Cloneles granulifera very abundant, Derbyia crassa, D. cymbula, echinoid spines, Euomphalus sp. common, valved Composita ovata common, crinoid columnals, trilobites, Lissochonetes geinitzianus, Lingula carbonaria, Polypora sp., Rhombopora sp. 7.3

Cottonwood limestone member. (6.4 feet)
Limestone, hard; light gray, weathers gray; massive, weathers in large irregular blocks; solution channels present, chert nodules present in the upper part. Fusulinids exceptionally abundant, in the upper half, crinoid columnals, echinoid spines, Lophophyllum proliferum, Composita ovata, and numerous small fossil fragments. 5.3
Limestone, hard; light gray, weathers gray; massive, weathers in thin plates; some limonite stains. . . . 1.1

Eskridge shale. (25.5 feet)
Shale, clayey, calcareous; gray-green, weathers light gray-green; blocky to thin-bedded; limonite streaks in upper part. 1.1
Shale, silty, very calcareous; gray, weathers light gray; blocky; some iron stain on fracture planes. . 3.8
Limestone, hard, somewhat argillaceous, gray, weathers gray; massive; numerous fine white specks. Juresania nebrascensis, Aviculopecten occidentalis, and Myalina copei. 0.4
Shale, silty with some clay, calcareous; gray-green, weathers gray; thin-bedded. 4.1
Shale, clayey, calcareous; maroon to maroon-gray, weathers maroon; thin-bedded. 1.9
Shale, clayey, calcareous; gray-green; thin-bedded to blocky; some limonite stains. 6.3
Shale, silty, calcareous; maroon; some green stains; blocky. 3.3
Covered interval. 7.6

Grenola limestone. (27.3 feet exposed)
Neva limestone member. (15.6 feet)
Limestone, hard, dense; gray-orange, weathers gray; massive, porous, weathers blocky; limonite-stained cavities. Echinoid spines, crinoid columnals, fusulinids, and numerous brachiopod fragments. Forms prominent hillside bench. 5.8

Limestone, hard; gray, weathers tan-gray; thin-bedded, weathers platy. Echinoid spines and plates abundant, Clonetes granulifera, and fusulinids. 1.6

Limestone, soft becoming hard at base; tan-gray, weathers gray; massive; porous, has rotten appearance; limonite stains common. Echinoid spines, Marginifera sp. 4.3

Shale, silty with some clay, calcareous; tan-gray weathers tan; thin-bedded. Crinoid columnals. . . . 2.4

Limestone, with thin shale parting near base, hard, somewhat argillaceous; tan; massive. Ambocoelia sp. and numerous fossil fragments. 1.5

Salem Point shale member. (7.9 feet)

Shale, mostly covered, clayey and silty, calcareous; tan to gray-green, weathers tan; thin-bedded; numerous calcareous plates on weathered surface, a very calcareous lens three feet from the base. 7.9

Burr limestone member. (4.3 feet exposed)

Limestone, hard somewhat argillaceous; tan-gray, weathers gray; massive to platy. Aviculopecten occidentalis, Aviculopinna sp., Pleurophorus albequus abundant, Hyalina sp. Most fossils are limonite-stained. . . 2.1

Shale, silty, very calcareous; tan; blocky. 1.5

Limestone, hard, argillaceous nodules present; tan-gray, weathers light gray; massive, blocky, limonite-stained. Osagia and microfossils present. 7

Base covered.

Section 20

This section from the Hooser shale member of the Bader limestone to the Neva limestone member of the Grenola limestone, inclusive, is exposed in a road cut in the [illegible] sec. 9, T. 11 S., R. 7 E.

	Feet
Soil, silty; dark; some colluvium	2 +
Bader limestone. (14 feet exposed)	
Hooser shale member. (5.5 feet exposed)	
Shale, exposed in road, vari-colored.	5.5
Kiss limestone member. (8.5 feet)	
Limestone, hard; tan-gray; massive, weathers to rectangular blocks; porous. Brachiopod fragments. . .	1.6
Limestone, tan-gray, weathers tan; massive; weathers rotten near the base; porous; limonite-stained. Meekella striatocostata and Derbyia crassa.	1.7
Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded. Derbyia crassa, Rhombopora sp., very abundant, Polypora sp., Meekella striatocostata, echinoid spines, Composita sp., and crinoid columnals.	3.9
Limestone, argillaceous; olive drab, weathers tan; blocky, weathers shaly and nodular.	1.3
Stearns shale. (14.4 feet)	
Shale (mostly covered), clayey with some silt, calcareous; olive drab, weathers gray; thin-bedded; contains calcareous nodules and a few thin limestone lenses.	14.4
Beattie limestone. (13.8 feet)	
Morrill limestone member. (1.2 feet)	
Limestone, soft; tan-brown, weathers tan; massive, weathers rotten; porous.	1.2
Florena shale member. (6.9 feet)	
Shale (partly covered), silty, calcareous; tan-gray, weathers tan; thin-bedded. Chonetes granulifera very abundant, Derbyia crassa, D. cymbula, Polypora sp. fusulinids, Rhombopora sp., crinoid columnals, echinoid spines, Composita ovata, C. subtilita, Stenopora sp., Dictyoclostus americanus, and trilobites.	6.9
Cottonwood limestone member. (5.7 feet)	
Limestone, hard; gray; massive, weathers to large blocks; somewhat porous, solution channels, occasional chert nodules. Fusulinids abundant, Dictyoclostus americanus, echinoid spines, crinoid columnals and Derbyia crassa.	5.3

Limestone, soft, argillaceous; grey-brown, weathers grey; massive, weathers shaly; iron-stained, brecciated. Polypora sp., ostracods and other microfossils. . . 0.4

Sakridge shale. (30.8 feet)
Shale, silty, very calcareous; light grey; thin-bedded to blocky; calcareous nodules and stains, iron stains near base. 4.7
Shale, silty, calcareous; violet; thin-bedded to blocky; iron stains on fracture planes. Fleuropherus albequus and Aviculopecten occidentalis. 3.1
Limestone, hard, dense; grey, weathers tan-grey; massive, weathers shaly on top; iron stains on fracture planes. 1.1
Shale, clayey, calcareous; tan-grey; blocky; calcareous nodules, limonite-stained. 3.0
Shale, clayey, calcareous; grey-green; blocky. 3
Shale, silty, calcareous, numerous calcareous lenses; maroon-grey, weathers light maroon; thin-bedded to blocky; iron stains on bedding planes. 4.7
Limestone, hard, argillaceous; grey; massive, weathers blocky; limonite stains on fracture planes. Myalina sp., Aviculopecten occidentalis. 4
Shale, clayey with some silt, calcareous; olive drab, weathers grey; thin-bedded; thin limestone lens in the upper part; limonite stains on bedding planes. . 2.1
Shale, silty, calcareous; grey-green, weathers light green; blocky; heavily limonite-stained in the top part. 1.3
Shale, clayey with some silt, calcareous; purple grading down to maroon, weathers purple; blocky. 2.1
Shale, clayey with some silt, very calcareous; light grey; thin-bedded; lenticular; iron stains. 2
Shale, silty with some clay, calcareous; grey-brown, weathers grey; thin-bedded; limonite-stained, some purple stains. 1.2
Shale, clayey, calcareous; violet with some purple stains, weathers light grey; thin-bedded. 1.0
Shale, silty, calcareous; purple; blocky. 1.7
Covered interval. 3.9

Grenola limestone. (9.7 feet exposed)
Neva limestone member. (9.7 feet exposed)
Limestone, hard, slightly argillaceous at base; tan-grey, weathers light grey; massive, weathers blocky. Echinoid spines and occasional brachiopod fragments. . . .9
Shale, silty, calcareous; tan-grey, weathers tan; thin-bedded; calcareous nodules. 2.4
Limestone, hard; tan, weathers tan-grey; massive. . . 4.1
Shale, silty, calcareous; tan-grey, weathers grey; thin-bedded. 1.1
Limestone, soft, tan-grey, weathers grey; massive; porous, heavily limonite-stained. 1.2

Base covered.

Section 21

This section from the Pasly Creek shale down to the Cottonwood limestone member of the Seattle limestone, inclusive, is exposed in a road cut in the SE¼ NE¼ sec. 20, T. 2 S., R. 8 E.

	Feet
Colluvium, silt and rock fragments.	2 -
Pasly Creek shale. (15.35 feet exposed)	
Shale, clayey with some silt, calcareous; tan-gray, weathers tan; thin-bedded.	3.6
Limestone, hard, dense in upper part; tan-gray, weathers tan; massive, weathers blocky; limonite stains and nodules. Aviculopecten occidentalis and fossil fragments.	3.1
Shale, silty with some clay, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; calcareous zone near the base, iron-stained.	3.2
Shale, silty calcareous; maroon, weathers purple; blocky.	.15
Shale, silty, calcareous; green, weathers light green; blocky to thin-bedded; iron and carbon stains on the bedding planes.	.7
Shale, silty, calcareous; maroon mottled with purple at the base and top; blocky.	2.9
Shale, clayey, calcareous; green mottled with maroon in upper part; thin-bedded.	1.4
Shale, clayey, calcareous; brown, weathers tan; thin-bedded; calcareous lens in upper part.	.3
Bader Limestone. (17.0 feet)	
Middleburg limestone member. (3.8 feet)	
Limestone, hard, somewhat crystalline, dense in part; olive drab, with maroon stains on the weathered surface; massive.	.7
Shale, silty, calcareous; gray becoming black at the base; thin-bedded; calcareous zone in the upper part.	.5
Limestone, dense; gray, weathers light gray; massive, weathers platy in upper part. Aviculopecten occidentalis, Polypora sp., Pseudomonotis hawni, Pleurophorus sp., and crinoid columnals. Forms small hillside bench.	2.6
Looser shale member. (7.7 feet)	
Shale, clayey with some silt, slightly calcareous; olive-drab, weathers tan; blocky; some calcareous lenses.	3.9
Shale, silty, calcareous; maroon; blocky to thin-bedded.	2.1

Shale, silty, calcareous; light gray; blocky; lenticular. 0.15
Shale, clayey, noncalcareous; maroon to purple, weathers purple; blocky. 2
Shale, silty, calcareous; light green-gray, weathers light gray; thin-bedded. 45
Shale, clayey with some silt, calcareous; maroon; blocky. 2
Shale, silty, calcareous; light gray-green, weathers light gray; thin-bedded. 7

Rias limestone member. (6.3 feet)
Limestone, argillaceous; gray, weathers light gray; massive; limonite-stained. 1.35
Shale, clayey with some silt, calcareous; olive drab, weathers tan; blocky. 3
Limestone, argillaceous; gray, weathers light gray; massive; lenticular. 65
Shale, silty, calcareous; tan; blocky; limonite-stained. .45
Shale, clayey with some silt, slightly calcareous; dark olive drab with some orange streaks, weathers gray; blocky. 8
Limestone, argillaceous; gray, weathers light gray; massive, weathers irregularly; lenticular. 1.95

Stearns shale. (12.9 feet)
Shale, silty, calcareous; tan, weathers tan-gray; blocky to thin-bedded; thin calcareous lenses. 4.2
Shale, silty, calcareous; gray-orange with black and and gray areas, weathers tan; blocky; iron and carbon nodules. 2
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded. 35
Shale, clayey, calcareous, carbonaceous; black; fissile. .85
Shale, silty, slightly calcareous; olive drab, weathers tan; blocky. 2.05
Limestone, argillaceous; tan-gray, weathers tan; massive; fractures easily; lenticular; iron-stained. 4
Shale, clayey with some silt, noncalcareous; dark gray, weathers light gray; thin-bedded to blocky; iron-stained. 3.2
Shale, silty, calcareous; maroon; thin-bedded; lenticular; stained light gray. 4
Shale, clayey, slightly calcareous; olive drab with maroon streaks in the upper part, weathers light gray; thin-bedded. 1.3

Seattle limestone. (15.2 feet exposed)
Morrill limestone member. (2.3 feet)
Limestone, dense, argillaceous; light gray, weathers tan; massive. 6
Shale, clayey with some silt, slightly calcareous; gray, weathers light gray; thin-bedded. 95

Limestone, argillaceous; dark gray, weathers tan; massive, weathers platy in upper part. Crinoid columnals, echinoid spines, and brachiopod fragments. 0.75

Florena shale member. (7.0 feet)

Shale, clayey with some silt, calcareous; olive drab, weathers tan; thin-bedded. Fenestella sp., Meekella striatocostata, Derbyia crassa, and Composita sp. . 1.3

Shale, silty, very calcareous; gray, weathers light gray; blocky to platy. Chonetes granulifera, Derbyia crassa, and Composita ovata. 2.2

Shale, silty, calcareous; olive drab, weathers tan; thin-bedded to blocky. Chonetes granulifera, Dictyoclostus americanus, Straparolus sp., Allorisma terminale, Meekella striatocostata, Composita ovata, crinoid columnals, fusulinids, echinoid spines, Derbya wabaunsensis, D. symbula, Rhombopora sp., Polypora sp., and Fenestella sp. 3.6

Cottonwood limestone member. (5.9 feet exposed)

Limestone, hard, dense; light gray, weathers tan; massive; chert nodules in middle and upper parts. Fusulinids very abundant in upper part. 5.9

Base covered.

Section 22

This section from the Grouse limestone to the Burr limestone member of the Brenola limestone, inclusive, is exposed in a road cut in the NE¼ NW¼ NE¼ sec. 7, T. 11 S., R. 9 E.

	Feet
Top covered, colluvium and Hue Rapids shale	
Grouse limestone. (7.2 feet exposed)	
Limestone, hard, dense; tan-brown, weathers tan; platy to thin-bedded.	0.2
Limestone, hard, crystalline; gray, weathers tan; massive, weathers platy.	.5
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded.	.2
Limestone, hard; tan-gray, weathers tan; platy with numerous shale partings.	.5
Shale, silty, noncalcareous; tan-gray, weathers tan; thin-bedded.	.1
Limestone, hard; gray-brown, weathers tan; platy.	.2
Shale, silty, calcareous; gray, weathers tan; thin-bedded.	.1
Limestone, hard; tan-gray, weathers tan; massive, weathers platy; thin shale parting.	.4
Shale, silty, calcareous; gray, weathers tan; thin-bedded.	.2
Limestone, hard; gray, weathers light gray; massive, weathers platy to a shale appearance.	1.15
Limestone, hard, dense; gray, weathers light gray; massive, weathers blocky at the top and platy at the base; thin shale parting in middle.	.7
Shale, silty, noncalcareous; tan-gray, weathers tan; thin-bedded.	.05
Limestone, hard; gray-brown, weathers light gray; massive, weathers to small thin chips.	.3
Shale, silty, calcareous; tan; thin-bedded to platy.	.2
Limestone, hard, crystalline; tan-gray, weathers gray; massive, weathers blocky. Fossil fragments in the upper part. Forms hillside bench.	1.8
Shale, silty, slightly calcareous; tan; thin-bedded.	.1
Limestone, hard; gray, weathers tan; massive, weathers blocky.	.5
Wasly Creek shale. (23.5 feet)	
Shale, clayey, slightly calcareous; gray-green, weathers light green; thin-bedded.	6.7
Limestone, hard; tan-gray, weathers tan; massive, weathers platy. Rhombopora sp., and some algae.	.3
Shale, silty, slightly calcareous; tan-gray, weathers tan; thin-bedded.	.05

Limestone, hard; light gray, weathers tan; massive weathers slabby. Rhombopora sp., Streparolus sp., algae?, Derbyia sp., and brachiopod fragments. . . . 1.7
Shale, slightly silty, slightly calcareous; gray-green, weathers light green; thin-bedded. 4.2
Shale, silty, calcareous; maroon; blocky and irregular. 1.5
Shale, silty, slightly calcareous; gray-green, weathers light gray; blocky to thin-bedded. 1.45
Shale, silty, noncalcareous; maroon; blocky to thin-bedded. 2.9
Shale, silty, calcareous; maroon mottled with gray-green; thin-bedded to blocky. 3.3
Shale, silty, slightly calcareous; gray-green, weathers tan-gray; thin-bedded. 1.5

Bader limestone. (17.65 feet)
Middleburg limestone member. (3.45 feet)
Limestone, hard, crystalline; tan-gray, weathers light grey; massive, weathers blocky. Algae. 0.75
Limestone, hard, argillaceous; tan-gray, weathers tan; massive, weathers blocky and platy. 2.7

Hooser shale member. (7.8 feet)
Covered interval. 7.8

Kiss limestone member. (6.4 feet)
Limestone, hard; gray; massive, weathers blocky and porous; limonite and iron-stained. Some fossil fragments. 1.9
Limestone, soft, argillaceous; tan-brown, weathers tan; massive, weathers blocky to platy, porous; calcite-lined cavities, limonite-stained. Derbyia crassa, Aviculopecten occidentalis, and Meekella striatocostata. 1.2
Shale, silty, calcareous; tan-gray, weathers gray; thin-bedded; limonite-stained in upper part. Meekella striatocostata, Derbyia crassa, Dictyoclostus sp., Chonetes granulifera, crinoid columnals, Composita sp., Rhombopora sp., and Fenestella sp. . 1.6
Limestone, medium hard; gray, weathers light gray; massive, weathers in small chips; limonite-stained. Loxonema sp., few ostracods, crinoid columnals, and Fenestella sp. 1.8

Stearns shale, (17.6 feet)
Shale, silty, calcareous; olive drab, weathers gray; thin-bedded becoming slightly platy. 8.7
Covered interval. 8.5

Beattie limestone. (13.1 feet)
Morrill limestone member. (0.8 feet exposed)
Limestone, soft; tan-brown; massive, weathers porous and rotten; calcite crystals common on the top surface. .8

Florena shale member. (6.5 feet)
Shale, clayey with some silt, noncalcareous in middle; tan-gray, weathers tan; thin-bedded; calcareous plates and nodules in upper part. Fossils rare. . . 6.5

Cottonwood limestone member. (5.7 feet)
Limestone, hard, fine-grained; tan-gray; massive, weathers to large blocks; chert nodules common in upper part with a few nodules in lower part. Fusulinids are abundant in the upper half, crinoid columnals, echinoid spines, Derbyia sp., and brachiopod fragments. 5.1
Limestone, hard; tan-gray, weathers tan; massive, weathers shaley. 0.6

Eskridge shale. (22.3 feet)
Shale, (partly covered) silty, calcareous; gray-green; thin-bedded to blocky; calcium carbonate and limonite stains in upper part. 8.3
Limestone, hard, slightly argillaceous; gray, weathers light gray; massive, weathers blocky. Aviculopecten occidentalis, Hyalina sp., and Pseudomontis fawni. . 0.2
Shale, silty, calcareous; gray, weathers light gray; thin-bedded. 3
Shale, clayey, noncalcareous; maroon; blocky; iron-stained. 5
Shale (partly covered), clayey, calcareous; gray-green to tan; thin-bedded to blocky. 12.5

Grenola limestone. (33.5 feet)
Neva limestone member. (16.6 feet)
Limestone, hard; tan-gray, weathers gray; massive, weathers blocky to porous in upper part; limonite-stained. Numerous fossil fragments. 1.3
Limestone, medium hard; tan-gray, weathers gray; massive, weathers in small chips; two shale partings. Chonetes granulifera, fusulinids, crinoid columnals, echinoid spines and Derbyia sp. 4.7
Limestone, hard, dense; light gray, weathers gray; massive, weathers blocky. Echinoid spines are abundant. 1.7
Limestone, soft, slightly brecciated; tan-gray, weathers tan; massive, weathers with a rotten, porous, nodular appearance; more resistant in basal part. Fossil fragments. 5.7
Shale, silty, with some clay, calcareous; tan-gray, weathers tan; thin-bedded. 2.8
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers platy; iron-stained. Few microfossils. . . .4

Salem Point shale member. (8.5 feet)
Shale, silty with some clay, calcareous; tan-gray, weathers tan; thin-bedded. 5.1
Limestone, soft, argillaceous; gray, weathers tan; massive, weathers blocky; some limonite specks. . . .3

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded, limonite-stained. 3.1

Burr limestone member. (8.4 feet)

Limestone, hard; gray-brown, weathers gray; massive, weathers thin-bedded; heavily limonite-stained at top, porous. 1.1

Shale, silty, calcareous; gray, weathers light gray; thin-bedded. 0.2

Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; two thin shale partings. 2.3

Shale, silty, calcareous; tan-gray, weathers tan; blocky. 5

Limestone, soft, argillaceous; tan-gray; massive, weathers blocky. Pleuropleurus elbequus and Aviculopecten occidentalis very abundant. 2

Shale, clayey, calcareous; dark gray, weathers gray; thin-bedded to blocky. 1.5

Limestone, hard, argillaceous in upper part; gray; massive, weathers blocky to platy in top part; limonite-stained. Aviculopecten occidentalis, and fossil fragments. 2.6

Base covered.

Section 23

This section from the Threemile limestone member of the Wreford limestone to top of the Wind limestone member of the Beder limestone, inclusive, is exposed in a road cut in the NW¼ NE¼ sec. 25, T. 10 S., R. 8 E.

	Feet
Wreford limestone. (3.2 feet exposed)	
Threemile limestone member. (9.2 feet exposed)	
Top covered, soil, silty, black; some chert gravel. .	3 ±
Limestone, hard, dense; gray, weathers light gray; massive, weathers blocky, chert nodules. Crinoid columnals and fossil fragments.	0.2
Limestone, hard, dense; gray, weathers tan; massive, weathers, blocky.	.6
Limestone, hard, dense; gray, weathers light gray; massive, weathers to irregular pieces; some chert nodules. Some fossil fragments.	.3
Limestone, hard, dense; light gray, weathers tan; massive, weathers blocky. Numerous fossil fragments. .	.5
Shale, silty, calcareous; gray, weathers tan; thin-bedded to platy. Dictyoclostus sp., Derbia sp., crinoid columnals and Composita sp.	.65
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; two chert lenses. Wellerella sp., crinoid columnals, echinoid spines, Derbyia crassa, and fossil fragments.	1.9
Shale, silty, calcareous; gray, weathers light gray; thin-bedded; numerous small limonite nodules. . . .	.05
Limestone, hard, dense; tan-gray weathers light gray; massive, weathers blocky; lenticular. Fossil fragments	.1
Shale, silty, calcareous; tan-gray to gray, weathers gray-green; thin-bedded. Crinoid columnals, Cloneties granuliferus, Dictyoclostus americanus, D. portlockianus, Juresania nebrascensis, Meekella striatocostata, Composita sp., Neospirifera sp., and Derbyia crassa.	2.7
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers irregularly. Numerous fossil fragments. .	1.2
Speiser shale. (11.4 feet)	
Shale, silty, noncalcareous; tan-gray, weathers tan; thin-bedded to blocky.	.2
Shale, silty, slightly calcareous; dark gray to tan-gray, weathers tan; thin-bedded to blocky.	1.2
Limestone, hard; gray, weathers tan-gray; massive, weathers blocky; small calcite nodules.	1.5
Shale, silty, noncalcareous; green, weathering light green; blocky.	2.75

Shale, clayey, noncalcareous; purple, mottled with green in middle; blocky. 1.4
Shale, clayey, noncalcareous; green grading downward to gray-brown; thin-bedded. 0.8
Shale, silty, slightly calcareous; brown; blocky to thin-bedded. 7
Shale, silty, calcareous; gray, weathers light gray; thin-bedded to blocky. 4
Shale, silty, noncalcareous; greenish-purple, weathers light purple; blocky. 1.1
Shale, clayey, noncalcareous; green, weathers light green; blocky. 1.4

Funston limestone. (6.5 feet)
Limestone, medium hard; tan-gray, weathers tan; massive, weathers blocky in upper and lower parts, and shaly to platy in middle part, very porous at base; two thin shale partings with a more massive shale in upper part. 5.9
Shale, clayey, slightly calcareous; gray, weathers tan-gray; thin-bedded; numerous limonite stains. 1.1
Limestone, hard, fine-grained; tan, weathers tan-gray; massive, weathers blocky and porous; calcite-filled pore spaces. 1.5

Blue Rapids shale. (20.4 feet)
Shale, clayey and silty, noncalcareous to calcareous; maroon and green at the base becoming tan-gray in the upper half; thin-bedded to blocky; some limonite stains; thin argillaceous limestone in lower part. 20.4

Crouse limestone. (8.4 feet)
Limestone, hard, fine-grained; tan-gray, weathers tan; massive, weathers platy; numerous thin shale partings 5.7
Limestone, hard, dense; tan-gray; massive, weathers blocky and porous, numerous fossil fragments in top part. 2.7

Easly Creek shale. (20.2 feet)
Shale (mostly covered), silty, calcareous; tan to gray, weathers tan; thin-bedded; limonite-stained. 7.1
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky to shaly; some iron stains. Numerous bryozoan fragments, Polypora sp., Rhombopora sp., and crinoid columnals. 9
Shale, silty, calcareous; tan-gray grading downward to gray-green at base; blocky; limonite stains on fracture planes. 2.9
Shale, silty, calcareous; maroon mottled with gray-green in the upper part; blocky. 1.7
Shale, clayey with some silt, calcareous; gray to light green; blocky. 9
Shale (mostly covered), gray-green and maroon. 6.7

Bader limestone. (13.8 feet exposed)
Middleburg limestone member. (5.4 feet)
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; limonite-stained. Numerous fossil fragments. 0.4
Shale, clayey, calcareous; black to gray, weathers gray; fissile; limonite-stained. 5
Limestone, hard; tan to gray, weathers tan-gray; massive, weathers blocky to shaly near the base; some limonite stains. 2.9

Hooser shale member. (10.1 feet)
Shale, silty, calcareous; tan-gray to gray-green, weathers tan-gray; blocky; iron stains on fracture planes. 5.9
Shale, silty, calcareous; maroon mottled with green lenses; blocky; iron stains on the fracture planes. 3.1
Covered interval. 1.1

Top of Nisa limestone.

Section 24

This section from the Havensville shale member of the Wreford limestone to the Crouse limestone, inclusive, is exposed in a road and railroad cut in the SW¼ NE¼ sec. 6, T. 5 S., R. 7 E.

	Feet
Soil and colluvium.	2 ±
Wreford limestone. (10.0 feet)	
Havensville shale member. (3.0 feet)	
Shale, silty, calcar ous; tan-gray; thin-bedded; calcium carbonate nodules, limonite-stained.	3.0
Threemile limestone member. (7.0 feet)	
Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocky; chert nodules; limonite-stained.	0.2
Shale, silty, calcareous; tan-gray; thin-bedded; chert nodules. Echinoid spines.	.8
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; three definite chert lenses, chert nodules; limonite-stained. *Allorisma* sp., and *Dictyoclostus americanus*.	4.0
Shale, silty, calcareous; tan-gray, thin-bedded. . . .	.1
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky to shaly at base; chert nodules. *Aviculopinna* sp., *Aviculopecten occidentalis*, *Derbyia crassa*, *D. Fooseriensis*, and *Composita* sp.	.7
Shale, silty, calcareous; olive drab; thin-bedded; some limonite stains.	.3
Limestone, hard; light gray, weathers tan-gray; massive; chert lens; limonite-stained.	.95
Speiser shale. (17.0 feet)	
Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded. Crinoid columnals, echinoid spines, *Juresania nebrascensis*, *Derbyia crassa*, and brachiopod fragments.	2.0
Limestone, hard; gray-brown, weathers tan; massive, weathers blocky; some limonite stains. Microfossils in basal part.	.9
Shale, silty, calcareous; gray-green with purple tint at base, weathers light gray-green; thin-bedded; some limonite stains on bedding planes.	2.9
Shale, clayey, with some silt, calcareous; maroon; thin-bedded to blocky.	2.0
Shale, clayey, calcareous; gray-green, weathers light gray-green; blocky.	.4
Shale, silty, slightly calcareous; maroon to purple, weathers purple; blocky.	1.3

Shale, clayey with some silt; calcareous; gray-green, weathers light gray-green; blocky. 0.3
Shale, silty, calcareous; maroon; blocky. 2.6
Shale, silty, calcareous; purple; blocky. 1.2
Shale, silty, calcareous; gray-green, weathers light gray-green; thin-bedded; some iron stains. 6
Shale, silty, very calcareous; purple to maroon; blocky to massive. 1.2
Shale, silty, calcareous; maroon mottled with green; thin-bedded. 7
Shale, clayey, calcareous; green, weathers gray-green; thin-bedded; limonite-stained. 9

Funston limestone. (5.6 feet)
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky to porous at top; maroon-stained. . 1.5
Shale, clayey, calcareous; green with maroon and purple stains, weathers gray-green; thin-bedded. 1.1
Limestone, hard, slightly dense; gray, weathers tan-gray, massive, weathers blocky; maroon stains on weathered surface. 1.1
Shale, clayey with some silt, calcareous; gray-green to light green at the base, weathers gray-green; thin-bedded; some limonite stains. 7
Limestone, hard, dense, argillaceous in upper part; gray, weathers tan-gray; massive, weathers rotten and blocky in middle part. 1.2

Blue Rapids shale. (19.2 feet)
Shale (partly covered), silty, calcareous; tan; thin-bedded to blocky; numerous thin arenaceous limestone lenses and nodular in upper part. 11.2
Shale, clayey, calcareous; tan-gray, weathers tan; thin-bedded; numerous thin calcareous lenses. . . . 1.1
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; numerous thin calcareous lenses. 4
Shale, silty, calcareous; purple to gray-green, weathers purple; blocky; iron-stained. 6.9

Crouse limestone. (8.5 feet exposed)
Limestone, hard to soft, dense; tan to grey, weathers tan; massive, weathers in thin beds in the top part and is blocky in lower part; iron-stained. 8.5

Section 25

This section from the Schroyer limestone member of the Wreford limestone to the top of the Crouse limestone, inclusive, is exposed in a road cut in the SW¼ NW¼ sec. 33, T. 10 S., R. 8 E.

	Feet
Weathered limestone and flint.	1 ±
Wreford limestone. (35.05 feet exposed)	
Schroyer limestone member. (2.05 feet exposed)	
Limestone, hard, dense; light gray to gray-orange, weathers tan-gray; massive, weathers blocky and irregular; flint nodules common. Echinoid spines and brachiopod fragments.	0.9
Limestone, medium hard; light gray, weathers tan; massive, weathers irregular; porous. Fossil fragments.	.5
Limestone, hard; tan to light gray; massive, weathers blocky; flinty.	.15
Limestone, hard; light gray, weathers tan; massive, weathers irregular. Echinoid spines, and brachiopod fragments.	.4
Limestone, hard; light gray to gray-orange; massive, weathers irregular; cherty. Brachiopod fragments. .	.3
Havensville shale member. (24.3 feet)	
Shale, silty, slightly calcareous; light gray, weathers tan; thin-bedded.	1.1
Shale, silty, calcareous; gray-green; blocky.	.2
Celestite, (lentil) light cream; weathers gray-orange.	.1
Shale, silty, calcareous; tan-gray; thin-bedded; numerous nodules of calcite and celestite, some geodes of calcite.	2.8
Limestone, crystalline; gray-orange, weathers tan; massive, weathers irregular; lenticular; geodal and some small nodules of celestite, limonite stains.	1.1
Shale, silty with some clay, noncalcareous; gray-brown, weathers tan; blocky.	1.3
Limestone, hard; gray-brown, weathers tan; lenticular.	.2
Shale, silty, calcareous; tan; thin-bedded; limonite stains on bedding planes.	.3
Limestone, hard; gray, weathers tan; massive, weathers blocky; limonite stains. Some fossil fragments. . .	.4
Shale, silty to clayey, calcareous; gray, weathers light gray; thin-bedded.	.1
Limestone, medium hard; light gray, weathers tan; massive, weathers blocky. Numerous fossil fragments.	1.0
Shale, silty to clayey, calcareous; tan-gray; thin-bedded.	9.4
Shale, silty with some clay, calcareous; dark gray, weathers gray; thin-bedded to fissile; limonite stains	2.4

Limestone, hard, crystalline; gray; massive, weathers blocky; lenticular. Aviculopecten occidentalis abundant and Myalina sp. 0.5
Shale, clayey, calcareous; tan-gray, weathers light gray; thin-bedded to blocky; limonite stains on bedding planes. 1.6
Limestone, hard; tan; massive, weathers platy; lenticular. Numerous fossil fragments. 8
Shale, clayey with some silt, calcareous; gray, weathers tan; thin-bedded; limonite stains. 1.0

Threemile limestone member. (8.7 feet)
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky. 1.2
Chert, dark gray to light gray; massive, weathers blocky; interbedded limestone lenses; limonite-stained. 9
Limestone, hard; light gray; massive, weathers blocky; porous. Forms hillside bench. 2.6
Chert; light gray to dark gray; massive, weathers blocky; lenticular, limonite-stained. 2
Limestone, medium hard; light gray, weathers tan; massive, weathers blocky; porous. 8
Chert; light gray to dark gray; massive, weathers blocky; lenticular; limonite-stained. 3
Limestone, dense; tan; massive, weathers blocky. Fossil fragments abundant. 4
Shale, silty, very calcareous; gray, weathers tan-gray; thin-bedded. Crinoid columnals, Jurassania nebrascensis, Composita ovata, and numerous fossil fragments. . . .5
Limestone, hard; light gray, weathers tan; massive, weathers blocky; numerous chert nodules. Crinoid columnals, echinoid spines, and fossil fragments. . 1.8

Speiser shale. (16.2 feet)
Shale, silty, calcareous; gray, weathers tan; thin-bedded; lenticular. Dictyoclostus americanus, Chonetes granulifera, and trilobites. 1
Limestone, dense; gray, weathers tan; massive, weathers blocky; lenticular. Echinoid spines. 5
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded. Dictyoclostus sp., Chonetes granulifera, Derbyia crassa, Jurassania nebrascensis, crinoid columnals, Polypora sp., Composita ovata. 8
Shale, silty, very calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; limonite stains on fracture planes. Ambocoelia sp., crinoid columnals, echinoid spines, and Derbyia sp. 3
Shale, silty, calcareous; tan-gray, weathers tan; blocky; limonite stains on fracture planes. Derbyia sp., and Ambocoelia sp. 1.1
Limestone, hard, dense, slightly crystalline; gray, weathers tan; massive, weathers blocky. Few fossil fragments. 1.2

Shale, silty, calcareous; gray, weathers tan-gray; blocky; limonite stains. 0.6
Shale, silty, calcareous; dark gray, weathers gray-green; blocky; limonite stains on fracture planes. 5
Shale, silty, calcareous; tan-green, weathers tan-gray; blocky; few limonite stains. 2
Shale, silty, calcareous; green with a purple tint, weathers light green; blocky. 4
Shale, silty, yellow-green mottled with purple in basal part, weathers tan-green; thin-bedded to blocky. 1.1
Shale, silty, calcareous; purple, weathering purplish-green; blocky; iron stains on fracture planes. 4
Shale, silty, very calcareous; green, weathers light green; blocky. 4
Shale, silty, calcareous; purple and green, weathers light green. 2
Shale, silty, calcareous; dark purple, weathers purple; blocky. 7
Shale, silty, calcareous; green, weathers light green; blocky; lenticular. 2
Shale, silty, noncalcareous; purple mottled with green; blocky. 1.8
Shale, silty, slightly calcareous; maroon; blocky. . . 1.5
Shale, silty, slightly calcareous; green mottled with maroon, weathers gray-green; blocky. 1.1
Shale, silty, calcareous; gray-green; blocky; numerous calcium carbonate nodules, limonite stains on nodules .4
Shale, silty, with some clay, noncalcareous; maroon mottled with green, weathers light maroon; blocky. . .7
Limestone, hard, argillaceous; tan; massive, weathers blocky; iron stains on fracture planes. 4
Shale, silty, calcareous; tan; blocky; iron stains on fracture planes. 6
Shale, silty with some clay, noncalcareous; dark green, weathers light green; blocky. 1.0

Funston limestone. (10.7 feet)
Limestone, soft; tan; massive, weathers blocky. . . . 2.0
Limestone, medium hard; cream; massive, weathers platy and blocky. 2.2
Limestone, hard, argillaceous; tan; massive weathers blocky; maroon stains on surface. 2
Limestone, medium hard; tan-brown, weathers tan; massive, weathers blocky. 1.8
Shale, silty, calcareous; tan, weathers light tan; thin-bedded. 3
Shale, silty, calcareous; tan, weathers light gray; blocky. 5
Shale, silty, noncalcareous; dark green mottled with brown, weathers light gray-green; thin-bedded. . . . 1.0
Limestone, hard, dense; tan-green, weathers tan; thin-bedded. 3
Shale, silty, calcareous; tan, weathers tan with maroon stains; thin-bedded. 4
Limestone, hard, semi-crystalline; light gray, weathers tan; massive, weathers blocky. Fusulinids and fossil fragments. 6

Limestone, medium hard; gray, weathers tan; massive, some small geodes. Fossil fragments abundant. . . . 0.9

Blue Rapids shale. (19.6 feet)

Shale, clayey with some silt, calcareous; gray to yellow-gray, weathers tan-gray; blocky; contains calcareous lenses; limonite stains on fracture planes. 2.6

Shale, silty with some clay, calcareous; dark gray, weathers gray; blocky; limonite stains on fracture planes. 4.8

Shale, clayey, calcareous; maroon; blocky to thin-bedded. 2.6

Shale, silty, calcareous; gray mottled with maroon, weathers light gray; blocky; limonite stains. . . . 1.6

Shale, silty, calcareous; maroon to gray to purple at the base, weathers gray-maroon; blocky. 1.9

Shale, silty, calcareous; gray-green, weathers light gray; blocky. 1.4

Shale, silty, slightly calcareous; speckled gray-green, weathers light gray; thin-bedded; limonite stains. . .9

Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded; contains thin calcareous lenses. . . . 3.8

Crouse limestone (0.8 feet exposed)

Limestone, hard, dense; tan-gray weathers tan; massive, weathers platy. 8

Base covered.

Section 26

This section from the Wymore shale member of the Matfield shale to the Funston limestone, inclusive, was measured in a road cut in the NE¼ NE¼ sec. 21, T. 11 S., R. 8 E.

	Feet
Soil, silty; gray-brown; chert fragments.	2 ±
Matfield shale. (5.5 feet exposed)	
Wymore shale member. (5.5 feet exposed)	
Shale, clayey, calcareous; vari-colored; thin-bedded to blocky.	5.5
Wreford limestone. (39.2 feet)	
Schroyer limestone member. (7.1 feet)	
Limestone, hard; shale parting in the middle part and near the base; tan; some limonite stains. Ostracods abundant in upper 0.8 foot.	2.3
Shale, silty, very calcareous; gray, weathers tan-gray; thin-bedded; thin limestone lenses and nodules. Dictyoclostus americanus, Composita sp., Allorisma terminale.	3.1
Chert, with some limestone; dark gray to gray; massive, weathers blocky.	0.4
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky.	.5
Chert, dark gray to gray; massive, weathers in large blocks.	.9
Limestone, hard; tan-gray, weathers tan; massive; lenticular, occasional fossil fragments.	.3
Chert, dark gray, weathers gray; massive, weathers blocky; lenticular; limonite stains.	.2
Limestone, hard, shale bed in middle part; tan-gray, weathers tan; chert nodules. Composita ovata, Rhombopora sp., Derbia crassa, crinoid columnals, and fossil fragments.	.9
Chert, dark gray, weathers gray; massive, weathers blocky; lenticular; limonite stains.	.2
Limestone, hard; tan-gray, weathers tan; massive; contains numerous chert nodules; limonite stains. Derbyia sp.	.6
Havensville shale member. (22.3 feet)	
Shale, clayey with some silt, slightly calcareous; olive drab to blue-gray, grading laterally into an olive drab shale, weathers tan; calcareous nodules at the base; some limonite stains.	4.1
Limestone, argillaceous; gray; massive, weathers irregular and platy. Aviculopinna sp., Allorisma terminale, Polypora sp., crinoid columnals, Ambocoelia sp., and numerous fossil fragments.	1.7

Shale, clayey, calcareous; dark gray, weathers blue-gray; thin-bedded. 1.9

Limestone, argillaceous; tan-gray, weathers tan; platy to massive; some limonite stains; massive zone occurs in central part; above it is a thin-bedded shale zone which grades into a platy zone. Myalina sp., and Pleurophorus sp., and at the very top there is a conglomeratic zone containing sharks teeth, microfossils, limonite nodules and clay balls. 2.1

Shale, clayey with some silt, calcareous; olive drab, weathers tan-gray; thin-bedded. 5.5

Shale, clayey, slightly calcareous; dark gray, weathers gray; thin-bedded. 4.5

Shale, silty, calcareous; olive drab to gray, weathers light gray; thin-bedded; very calcareous plates weather out; limonite stains. Aviculopecten occidentalis abundant, Derbyia crassa, Myalina sp., and Pleurophorus sp. 2.5

Threemile limestone member. (9.8 feet)

Limestone, hard; tan-gray, weathers tan; massive; chert nodules numerous in the basal part and occasional nodules scattered throughout with a prominent lens of chert in the upper part. Echinoid spines, crinoid columnals, occasional brachiopod fragments. 5.8

Limestone, hard; tan-gray, weathers tan; massive; porous; some limonite stains; chert nodules in the upper part. 1.5

Chert, dark gray to light gray; massive; lenticular. . .2

Limestone, soft; tan-brown, weathers tan; porous in central part. 5

Limestone, somewhat shaly toward base; hard; gray, weathers tan; massive; two chert bands in upper part; occasional limonite stains. Echinoid spines. . . . 1.4

Shale, silty, calcareous; gray-green, weathers tan-gray; thin-bedded. Dictyoclostus americanus, Composita ovata, crinoid columnals, and Amboccelia sp. 4

Limestone, hard; light gray, interbedded bands of dark gray; massive; chert nodules. 2.0

Speiser shale. (17.3 feet)

Shale, silty, calcareous; tan-gray, weathers light gray; thin-bedded; some limonite stains. Crinoid columnals, Derbyia sp., Chonetes granulifera, and Aviculopecten occidentalis. 2.9

Limestone, hard; gray, weathers tan; massive; thin shale parting near base. 1.0

Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded; numerous clay balls and limonite nodules; limonite stains in basal part. 3

Limestone, argillaceous; gray, weathers light gray; massive to nodular; limonite stains. 8

Shale, silty, highly calcareous; dark green, weathers light green; thin-bedded; heavily limonite-stained in the top part. 4

Shale, silty, noncalcareous; dark green, weathers green; blocky; iron stains on fracture planes. 0.4
Shale, silty, calcareous; light to dark green; weathers green; thin-bedded at top becoming blocky at base; limonite stains on fracture planes. 3.6
Shale, silty, calcareous; purple; blocky. 8
Shale, silty, calcareous; green; blocky; limonite stains in basal part. 3
Shale, silty, calcareous; maroon with purple and green mottling in upper part; blocky; some stains and nodules of limonite. 1.3
Shale, clayey, calcareous; gray-green; thin-bedded; limonite stains. 1.1
Limestone, argillaceous; gray, speckled with green, weathers tan to light gray; massive, top part weathers to small plates. 1.3
Shale, clayey, calcareous; gray-green, weathers light green; thin-bedded to blocky. 7
Shale, silty with some clay, calcareous; tan-gray, weathers tan. 2.1

Funston limestone. (3.0 feet exposed)
Limestone, hard, dense; gray, weathers tan; massive. . .6
Limestone, hard; gray, weathers tan; massive, blocky weathers irregularly; clay nodules, porous. 2.4

Base covered.

Section 27

This section from the Kinney limestone member of the Matfield shale to the Speiser shale, inclusive, is exposed in a stream bank in the SE¼ NE¼ sec. 15, T. 7 S., R. 6 E.

	Feet
Gravel, chert and limestone.	2 +
Matfield shale. (34.3 feet exposed)	
Kinney limestone member. (1.7 feet exposed)	
Limestone, soft, arenaceous appearance; gray-green; massive; porous.	1.7
Wymore shale member. (32.6 feet)	
Shale, clayey, slightly calcareous; gray-green; thin-bedded.	2.9
Shale, silty, calcareous; tan; thin-bedded.	0.7
Limestone, hard, partly argillaceous; gray, weathers tan; massive, weathers blocky; iron-stained.	.7
Shale, clayey and silty, noncalcareous; tan-gray, weathers tan; thin-bedded to blocky; carbon and limonite stains.	6.1
Shale, silty, calcareous; gray-green, weathers light green; blocky; limonite-stained.	3.5
Shale, silty and clayey, calcareous; maroon with green and purple stains in middle; blocky.	5.1
Shale, silty, slightly calcareous; purple with maroon tint, weathers purple; blocky; iron-stained.	4.2
Shale, clayey, calcareous; gray-green, weathers tan-gray; thin-bedded; iron-stained.	.8
Wreford limestone. (39.9 feet)	
Schroyer limestone member. (10.6 feet)	
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky. Microfossils abundant in upper part.	1.5
Shale, silty, with some clay; calcareous; gray-brown, weathers tan-gray; thin-bedded to blocky; some limonite stains.	2.7
Limestone, hard; light gray, weathers tan-gray; massive, weathers nodular; numerous chert nodules.	1.4
Shale, silty, calcareous; gray-brown, weathers tan-gray; thin-bedded. *Dictyoclostus portlockianus*.	.8
Chert, light gray to dark gray; massive, weathers blocky and irregularly.	.3
Limestone, hard; light gray, weathers tan-gray; massive, weathers irregularly and blocky. Fossil fragments. .	.6
Chert, some limestone at base; light gray to dark gray; massive, weathers blocky and irregularly.	1.0
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; some chert nodules, chert lens at top.	1.3

Chert, light gray to dark gray; massive, weathers blocky. 0.3
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky. 7

Ravensville shale member. (21.2 feet)
Shale, silty, calcareous; gray-green to olive drab, weathers tan-gray; thin-bedded; numerous calcareous nodules. 1.0
Limestone, medium hard; tan-gray; massive, weathers platy and to irregular blocks. 6
Shale, silty, calcareous; gray-green, weathers tan; thin-bedded; lenticular. 2
Limestone, soft, fine-grained; tan, weathers tan-gray; massive, weathers to irregular blocks; some iron stains. Some brachiopod fragments. 6
Shale, silty, calcareous; olive drab, weathers tan; thin-bedded; calcareous lenses; limonite-stained. . . .5
Limestone, medium hard, fine-grained; tan-gray; massive, weathers blocky to platy; iron stains abundant; slightly porous. Aviculopecten occidentalis and Euomphalus sp. 4.9
Shale, silty, with some clay, calcareous; dark gray, weathers gray; thin-bedded to fissile; calcareous lens in middle part and at top. 5.2
Limestone, hard, argillaceous; gray, weathers tan to gray; massive, shows thin bedding planes, weathers blocky to platy. Aviculopecten occidentalis very abundant, Juresania nebrascensis and Kyalina sp. . . 2.2
Shale, clayey with some silt, calcareous; dark gray, weathers gray; thin-bedded to blocky; some iron stains. 1.0
Limestone, argillaceous; dark gray, weathers gray; massive, weathers shaly; thin shale beds. 1.5
Shale, clayey, calcareous; dark gray, weathers gray; thin-bedded to fissile. 3.5

Threemile limestone member. (8.1 feet)
Limestone, hard; tan; massive, weathers shaly; some chert nodules in middle part. Crinoid columnals and brachiopod fragments. 1.4
Chert, light gray to dark gray; massive, weathers blocky; some iron stains; lenticular. 4
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky and irregularly; porous. 1.2
Chert, light gray to dark gray; massive, weathers blocky; numerous limonite stains; lenticular. 2
Limestone, soft; tan-gray; massive, weathers porous and rotten at the base; numerous limonite stains. 2
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; slightly porous. 1.4
Chert, light gray to dark gray; massive, weathers blocky; lenticular. 2
Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky. 6

Shale, silty, very calcareous; dark gray, weathers gray; thin-bedded; limestone lens in middle part. Crinoid columnals, and Derbyia sp. 1.3

Limestone, hard, somewhat crystalline; gray, weathers tan-gray; massive, weathers blocky; chert lens in middle part. 1.2

Spelser shale. (8.3 feet exposed)

Shale, silty, calcareous; gray; thin-bedded; calcareous lens in middle part. Crinoid columnals, Rhipidomella carbonaria, Polypora sp., Dictyoclostus americanus, Derbyia crassa, and Chonetes granulifera. 2.0

Limestone, hard, dense; gray with numerous black specks; massive, weathers blocky. 0.6

Shale, silty very calcareous; vari-colored shale with purple, green, and gray beds in upper part and maroon in lower part; blocky. 5.7

Base covered.

Section 28

This section from the Florence limestone member of the Barneston limestone to the top of the Schroyer limestone member of the Wreford limestone, inclusive, is exhibited in a road cut in SW¼ SE¼ sec. 18, T. 11 S., R. 7 E.

	Feet
Soil, silty, dark.	1 ±
Barneston limestone. (15.5 feet exposed)	
Florence limestone member. (15.5 feet exposed)	
Limestone and weathered chert, individual beds not measurable.	4.9
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; porous, limonite stains. Crinoid columnals, Euomphalus sp., Dictyoclostus americanus.	0.9
Chert, light gray to dark gray, massive, weathers blocky; fractures conchoidal; lenticular.	.25
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; lenticular; limonite-stained. . . .	.3
Chert; light gray to dark gray; massive, weathers to irregular blocks; fractures conchoidal; lenticular; limonite-stained areas. Trilobites, numerous fossil fragments on surface.	.4
Limestone, hard, dense; gray to tan-gray, weathers tan; massive, weathers blocky; chert nodules in thin lenses	2.3
Chert; light gray to dark gray; massive, weathers blocky; fractures conchoidal; lenticular; limonite-stained. Fenestella sp. and fossil fragments on outer surface.	.3
Limestone, soft; tan, weathers tan-gray; massive; porous in upper part; numerous chert nodules; iron-stained. Rhombopora sp., Fenestella sp., and Dictyoclostus americanus.	2.1
Shale, silty, calcareous; tan; thin-bedded.	.1
Limestone, hard, dense; tan, weathers tan-gray; massive; some chert nodules in upper part; iron streaks. Fusulinids and echinoid spines.	1.0
Chert, hard, dense; gray to light gray; massive, weathers in thin blocks; limonite-stained.	.3
Limestone, hard, dense; tan, weathering tan-gray; massive, weathers blocky; some chert nodules; lenticular. Echinoid spines.	.7
Chert; light-gray to dark gray; massive, weathers in small blocks; lenticular; conchoidal fracture. . . .	.35
Limestone, hard; tan-gray, weathers tan; massive; a thin chert lens in middle part, occasional chert nodules scattered throughout; thin shale parting near the base. Possibly microfossils, Polypora sp., Fenestella sp., Ambocoelia sp., echinoid spines, and crinoid columnals.	1.6

Matfield shale (76.2 feet)
Blue Springs shale member. (33.2 feet)
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; lenticular; calcareous nodules. Dictyoclostus sp., crinoid columnals, Derbyia sp., Rhombopora sp., and numerous fossil fragments. 1.7
Shale, silty, calcareous; gray-green grading down to tan, weathers tan; thin-bedded to blocky; grades laterally into a thin limestone; iron-stained. Allorisma terminale, Dictyoclostus sp., and Derbyia cymbula. 1.6
Shale, silty, calcareous; gray-orange; thin-bedded; limonite stains on fracture planes. 0.2
Shale, silty, calcareous, gray, weathers light gray; blocky; iron stains on bedding planes. Pleurophorus albequus. 3
Shale, silty, calcareous; tan-gray; thin-bedded; very lenticular; large calcium carbonate nodules; iron stains. 4
Shale, silty, slightly calcareous; gray-green, weathers light green; blocky. 1.1
Shale, clayey, calcareous; gray-green, weathers light green; thin-bedded; iron stains on bedding planes. . 5.9
Shale, clayey, calcareous; violet, green stains throughout; thin-bedded. 1.1
Shale, silty, calcareous; green, weathers light green, some violet stains in upper part; thin-bedded; iron stains on bedding planes. 2
Shale, silty, calcareous; maroon; blocky; lenticular. .5
Shale, silty, calcareous; light green; blocky; some calcareous lenses present; maroon stains on surface. .6
Shale, silty, calcareous; maroon; thin-bedded to blocky. 1.2
Shale, clayey, slightly calcareous; green; blocky. . . .45
Shale, silty, calcareous, maroon; thin-bedded to blocky. 2.4
Covered interval. 15.5

Kinney limestone member. (2.1 feet)
Limestone, soft, slightly dolomitic; tan; massive, weathers blocky; numerous black specks. Forms a small hillside bench. 2.1

Wymore shale member. (40.9 feet exposed)
Shale, clayey, slightly calcareous; green; blocky; limonite stains on fracture planes. 4
Shale, clayey, calcareous; maroon, tinted purple at the base; thin-bedded. 1.4
Shale, clayey, calcareous; greenish-gray to gray, weathers gray-green; thin-bedded. 2.7
Shale, clayey, calcareous; maroon; thin-bedded. 9
Shale, clayey, calcareous; yellowish-gray, weathers tan; thin-bedded. 6.9
Limestone, argillaceous, soft; tan-gray, weathers tan; massive, weathers blocky, iron stains on bedding planes. Myalina subquadrata, Aviculopecten occidentalis, and Myalina sp. 7

Shale, silty, very calcareous; tan-gray, weathers tan; thin-bedded; thin limestone lens in the middle part; limonite-stained areas.	5.2
Limestone, argillaceous, clay nodules; tan-gray, weathers tan; massive, weathers blocky; porous; heavily limonite-stained; lenticular.	1.3
Shale, silty, calcareous, tan-gray, weathers tan; thin-bedded; calcareous nodules.	9.5
Covered interval, colluvium.	11.9

Top of Schroyer limestone member of the Wreford limestone.

Section 29

This section from the Florence limestone member of the Barneston limestone to the Wymore shale member of the Matfield shale, inclusive, is exposed in a road cut in the NE¼ SW¼ sec. 10, T. 6 S., R. 7 E.

	Feet
Soil, silty, gray-brown.	2 ±
Barneston limestone. (19.2 feet exposed)	
Florence limestone member. (19.2 feet exposed)	
Limestone, hard; tan to light gray, weathers tan; massive, weathers blocky; numerous chert lenses and nodules. Echinoid spines, crinoid columnals and few fusulinids.	16.7
Shale, silty, calcareous; gray to gray-green, weathers tan; thin-bedded; numerous calcareous nodules. Echinoconchus sp., crinoid columnals, echinoid spines, and Derbyia sp.	0.6
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky to shaly; some limonite stains; chert nodules. Crinoid columnals, Derbyia crassa, D. cymbula, Juresania nebrascensis, fusulinids, Chonetes granulifera, Marginifera hystricula, and Rhombopora sp.	.7
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous nodules. Echinoid spines, and brachiopod fragments.	.4
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; chert nodules; some limonite stains. Fenestella sp., Derbyia crassa and numerous brachiopod fragments.	.8
Matfield shale. (44.1 feet exposed)	
Blue Springs shale member. (23.6 feet)	
Shale, silty, calcareous; gray, weathers light gray; thin-bedded; iron stains on bedding planes.	2.8
Shale, silty, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; numerous iron stains on bedding and fracture planes.	3.4
Shale, clayey with some silt, calcareous; maroon mottled with purple and gray-green; thin-bedded; iron-stained.	4.7
Shale, silty, calcareous; gray-green, weathers light gray-green; thin-bedded.	.9
Shale, silty, very calcareous; maroon; massive and very calcareous in the upper part, blocky in the lower part.	2.7
Shale, silty, calcareous; green, weathers gray-green; blocky.	.8

Shale, silty, calcareous; maroon with a purple tint in the upper part; thin-bedded. 1.7
Shale, clayey, calcareous; gray-green, weathers light gray-green; thin-bedded to blocky; iron stains on bedding planes. 1.1
Shale, clayey, calcareous; maroon becoming purple toward base, mottled with gray and light green in the middle; thin-bedded to blocky. 5.5

Kinney limestone member. (2.5 feet)
Limestone, soft; tan to light gray, weathers tan-gray with maroon stains; massive, weathers to irregular rounded blocks; chalky at the base. Microfossils abundant. 1.9
Shale, clayey, calcareous; gray-green, thin-bedded. . 0.2
Limestone, soft; tan; massive, weathers blocky; maroon-stained; numerous small calcite crystals. 4

Wymore shale member. (18.0 feet exposed)
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; blocky to thin-bedded; contains numerous thin calcareous lenses. 3.3
Shale, clayey, calcareous; olive drab mottled with gray, weathers tan; thin-bedded. 9.2
Shale, silty, calcareous; gray to gray-brown, weathers tan; thin-bedded to blocky; numerous calcareous lenses, cone-in-cone. 5.5

Base covered.

Section 30

This section from the Florence limestone member of the Barneston limestone to the Wymore shale member of the Matfield shale, inclusive, is exposed in a road cut in the SW¼ SW¼ sec. 21, T. 11 S., R. 8 E.

	Feet
Weathered limestone and soil.	1 ±
Barneston limestone. (11.0 feet exposed)	
Florence limestone member. (11.0 feet exposed)	
Limestone, hard; tan-gray, weathers tan; massive, weathers platy and irregularly. Crinoid columnals, Rhombopora sp., echinoid spine, Meekella striatocostata, Polypora sp., and Derbyia crassa.	0.15
Limestone, cherty; gray, weathering light gray; massive, weathers blocky; limonite-stained. Dictyoclostus portlockianus, crinoid columnals, echinoid spines. .	.6
Limestone, hard; tan to gray, weathers tan; massive weathers irregular; limonite-stained, contains chert nodules. Dictyoclostus sp., and Polypora sp. . . .	2.2
Limestone, hard; gray, weathers tan to light gray; massive, weathers irregularly; porous; chert nodules. Polypora sp., and echinoid spines.	2.5
Shale, silty, calcareous; light gray weathers tan; fissile; lenticular.	.2
Limestone, hard; tan; massive, weathers irregularly and blocky; chert lenses and nodules. Fusulinids, echinoid spines, crinoid columnals, Polypora sp., Rhombopora sp., and fossil fragments.	1.8
Shale, silty, calcareous; tan-gray, weathers tan; platy. Derbyia sp., Dictyoclostus sp., Polypora sp., and echinoid spines.	.1
Limestone, medium hard, argillaceous; gray, weathers tan; massive weathers platy to shaly. Dictyoclostus americanus, crinoid columnals, echinoid spines, and Derbyia sp.	.8
Shale, silty, calcareous; light tan; thin-bedded. . .	.2
Limestone, hard, argillaceous; gray, weathers tan-gray; massive weathers to very irregular blocks; some iron stains. Derbyia sp., Juresania nebrascensis, Dictyoclostus portlockianus, echinoid spines, Derbyia deercreekensis, D. crassa.	1.1
Matfield shale. (60.9 feet exposed)	
Blue Springs shale member. (18.8 feet)	
Shale, clayey, slightly calcareous; tan-gray, weathers tan; blocky. Allorisma terminale, Inteletes hemiplicatus, and Derbyia crassa.	.7
Limestone, medium hard, argillaceous; gray, weathers tan; massive, weathers blocky. Echinoid spines.	.7

Shale, silty, calcareous; gray, weathers light gray; fissile. Microfossils. 0.5
Limestone, hard, argillaceous; tan-green, weathers tan; massive, weathers irregularly; lenticular. 4
Shale, silty slightly calcareous; tan-gray, weathers tan; blocky; lenticular. 4
Limestone, medium hard, argillaceous; tan-gray, weathers tan; massive, weathers irregularly; lenticular. . . .2
Shale, silty, calcareous; gray, weathers light gray; blocky; limonite-stained. 2.1
Shale, clayey, slightly calcareous; gray, weathers tan; blocky. Upper part is more resistant to weathering. 2.6
Shale, clayey, calcareous; maroon to gray, weathers maroon; blocky; limonite-stained. 1.4
Limestone, hard, argillaceous; gray, weathers light gray; massive, weathers shaly; lenticular. 8
Shale, clayey, slightly calcareous; maroon; blocky to platy. 1.8
Shale, clayey, slightly calcareous; olive-green weathers light green; thin-bedded to fissile. 3
Shale, clayey, slightly calcareous; maroon; blocky to platy. 1.2
Shale, clayey, slightly calcareous; green, weathers light green; thin-bedded. 35
Shale, clayey, noncalcareous; maroon; thin-bedded to blocky. 2.4
Shale, slightly silty, slightly calcareous; green mottled with maroon, weathers light green; blocky. . 1.3
Shale, silty, slightly calcareous; maroon with green lenses, weathers maroon; blocky. 4
Shale, silty, noncalcareous; green, weathers light green; blocky to thin-bedded. 1.3

Kinney limestone member. (2.3 feet)
Limestone, soft, fine-grained; tan with green tint, weathers tan; massive weathers blocky and porous, the lower part weathers platy; surface is stained-maroon. Microfossils in upper part. 2.3

Wymore shale member. (39.8 feet exposed)
Shale, clayey, noncalcareous; green, weathers light green; blocky. 6
Shale, clayey, noncalcareous; green, weathers light green; thin-bedded to fissile; limonite stains in lower part, thin secondary calcite lenses. 1.7
Shale, clayey, slightly calcareous; green grading downward to yellow-green, weathers light green; thin-bedded; limonite stains on bedding planes. 2.1
Shale, clayey with some silt, calcareous; maroon; thin-bedded; thin calcite lenses. 7.7
Shale, clayey, slightly calcareous; green grading downward to yellow-green, weathers light green; thin-bedded to fissile. Composita sp., Rhombopora sp., Juresania nebrascensis, echinoid plates and spines, crinoid columnals, Derbyia deercreekensis, D. wabaunseensis, and D. crassa. 13.4

Limestone, hard; tan-gray, weathers tan; massive, weathers irregularly; lenticular. Crinoid columnals, Derbyia sp., microfossils abundant. . .	0.4
Shale, silty, calcareous; tan-gray, weathers tan; fissile to thin-bedded. Allorisma sp., and crinoid columnals.	1.2
Limestone, hard; light gray weathers tan; massive, weathers blocky; small clay balls in lower part. Crinoid columnals, echinoid spines. Derbyia crassa, and Allorisma sp. Forms small hillside bench.	2.4
Shale, silty, slightly calcareous; tan-green, weathers light gray; fissile to thin-bedded.	10.3

Base covered.

Section 31

This section from the Fort Riley limestone member of the Barneston limestone to the Easly Creek shale, inclusive, is exposed in a road cut in the NE¼ SW¼ sec. 29, T. [illegible] S., R. 7 E.

	Feet
Soil, silty and clayey; brown to gray.	2 ±
Barneston limestone (40.8 exposed)	
Fort Riley limestone member. (10.0 exposed)	
Limestone, hard; tan to tan-gray, weathers gray; massive, weathers blocky and platy at top; porous, some limonite stains. Echinoid spines abundant, Derbyia crassa, D. cymbula, crinoid columnals, Aviculopecten occidentalis, Dictyoclostus portlockianus, Ambocoelia expansa, Composita ovata, Polypora sp., Fenestella sp., Euomphalus sp., Rhombopora sp.	5.9
Shale, silty, calcareous; tan, weathers tan-gray; thin-bedded; contains a calcareous lens; some limonite stains. Composita ovata, Derbyia cymbula, echinoid spines, and crinoid columnals.	2.0
Limestone, hard, dense, somewhat crystalline; gray-orange, weathers tan; massive, weathers in irregular blocks; some iron stains. Echinoid spines, Fenestella sp., Rhombopora sp., Derbyia crassa, Dictyoclostus americanus, and Ambocoelia expansa.	2.1
Oketo shale member. (9.5 feet)	
Shale, silty with some clay, very calcareous; tan-gray to blue-gray, weathers tan; thin-bedded; numerous calcareous lenses. Derbyia crassa, Composita ovata, Meekella striatocostata, Dictyoclostus americanus, crinoid columnals, Polypora sp., Ambocoelia expansa, Rhombopora sp., echinoid spines, Aviculopecten occidentalis.	5.0
Limestone, hard, dense; tan-gray; massive, weathers blocky. Echinoid spines abundant, crinoid columnals and brachiopod fragments.	.9
Shale, silty with some clay, calcareous; tan; thin-bedded. Echinoid spines, crinoid columnals, Derbyia crassa, Ambocoelia expansa, Fenestella sp., Rhombopora sp., and Fistulipora sp.	3.6
Florence limestone member. (21.3 feet)	
Limestone, hard, dense; tan, weathers tan-gray; massive, weathers blocky; numerous chert nodules; some limonite stains. Crinoid columnals, Meekella striatocostata, echinoid spines, Derbyia cymbola, and Astartella sp.	2.9
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded. Echinoid spines.	.4

Limestone, hard, dense; tan-gray; massive, weathers blocky and irregularly; numerous chert lenses and nodules; iron-stained. Composita sp., Penestella sp., Polypora sp., echinoid spines, Derbyia cymbula, D. sp., Meekella striatocostata, and crinoid columnals. 11.9

Limestone, hard, dense; tan to gray, weathers tan-gray; massive, weathers blocky; alternating limestone and chert with massive chert lens at top, chert nodules; limonite-stained. Crinoid columnals, echinoid spines, fusulinids and Rhombopora sp. . . . 6.1

Matfield shale. (71.0 feet)

Blue Springs shale member. (24.9 feet)

Shale, silty with some clay, calcareous; tan; thin-bedded; calcareous nodules abundant, some limonite stains. 3.3

Limestone, hard; tan-gray, weathers tan; massive, weathers blocky. 0.9

Shale, silty, calcareous; tan; thin-bedded. 5.0

Shale, silty, slightly calcareous; gray-green, weathers dark gray; thin-bedded. 1.0

Shale, clayey, calcareous; light gray-green; thin-bedded; iron stains. 4.9

Shale, silty, calcareous; green, weathers light green; blocky; iron stains on fracture planes. 7

Shale, clayey, calcareous; light gray; mottled with maroon at base; thin-bedded. 2.1

Shale, silty with some clay, calcareous; maroon; mottled with light green; blocky. 1.4

Shale, silty, calcareous; gray-green; thin-bedded; some iron stains. 5

Shale, silty, calcareous; maroon with a few green stains; blocky; calcareous lenses. 2.1

Shale, clayey, calcareous; green; thin-bedded. 4

Shale, clayey, calcareous; maroon mottled with green; blocky to thin-bedded. 5.2

Shale, silty with some clay, slightly calcareous; green, weathers light green with a purple tint in upper part; thin-bedded to blocky; iron stains in middle part. 2.1

Kinney limestone member. (3.1 feet)

Limestone, medium hard, dense; light gray, weathers tan; massive weathers blocky; some fine black specks. A zone (0.2 foot thick) at very top contains ostracods 3.1

Wymore shale member. (43.0 feet)

Shale, clayey somewhat silty, noncalcareous; green, weathers light gray-green, purple stains in the middle; thin-bedded becomes blocky at base; some limonite stains. 6.6

Shale, very silty, slightly calcareous; tan with some gray zones; blocky to thin-bedded; numerous limonite stains. 20.9

Shale, silty, calcareous; olive drab weathers gray; blocky; numerous limonite-stains, and some carbon stains. 1.1

Shale, silty, calcareous; olive drab to gray-green mottled with maroon, weathers gray; thin-bedded to blocky; some iron stains, maroon nodules on weathered surface. 3.8

Shale, clayey, calcareous; gray-green to dark green, weathers tan-gray; blocky; numerous limonite stains. 4.3

Shale, clayey, calcareous; maroon; blocky. 0.4

Shale, clayey, calcareous; gray; blocky. 5

Covered interval. 5.4

Wreford limestone. (36.1 feet)

Schroyer limestone member. (8.1 feet)

Limestone (covered at base), hard, slightly crystalline; tan weathers tan-gray; massive, weathers blocky; limonite stains common. 2.3

Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky; numerous chert lenses and nodules. Crinoid columnals, Chonetes granulifera, Fenestella sp., echinoid spines, Ambocoelia planoconvexa, and numerous fossil fragments. 2.3

Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky; thick chert lens in middle, numerous chert nodules. Crinoid columnals, Chonetes granulifera, Juresania nebrascensis, echinoid spines, Dictyoclostus sp., brachiopod fragments. 1.8

Shale, silty, very calcareous; tan; platy, lenticular. .15

Limestone, hard, dense; light gray, weathers tan-gray; massive weathers blocky; chert lenses in upper part. Composita sp., and Ambocoelia sp. 1.6

Havensville shale member. (20.8 feet)

Shale, silty, calcareous; tan; thin-bedded; calcareous lenses. 3.3

Limestone, soft, dense, argillaceous in basal part; tan to tan-gray, weathers tan-gray; massive weathers shaly; porous, numerous limonite stains. 9

Shale (mostly covered), silty, calcareous; tan to tan-gray, weathers tan; thin-bedded to blocky; few calcareous lenses in upper part, some limonite stains. 16.6

Threemile limestone member. (7.6 feet)

Limestone, medium hard; tan, weathers tan-gray; massive, weathers blocky. Crinoid columnals and few small fusulinids. 4

Chert, hard, dense; light grey to dark gray; massive, weathers blocky; lenticular. 35

Limestone, hard, dense; tan-gray; massive, weathers blocky; slightly porous, some limonite stains in pores; thin shale lens at base. 1.2

Chert, hard, dense; light grey to dark gray; massive weathers to small blocks. 2

Limestone, hard, dense; tan-gray; massive, weathers blocky; porous, limonite stains in pores. 2.1
Chert, hard, dense; light gray to dark gray; massive, weathers blocky; lenticular. 0.3
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky; porous, limonite stains in pores; some chert nodules in lower part, thin shale parting in the middle part. 1.5
Shale, silty, calcareous; tan-gray; thin-bedded. Crinoid columnals, echinoid spines, Derbyia sp., and Composita sp. 6
Limestone, hard; light gray, weathers tan; massive; one chert lens and few chert nodules; some limonite stains. Crinoid columnals and echinoid spines. 1.0

Speiser shale. (13.6 feet)
Shale, silty with some clay, calcareous; tan to tan-gray, weathers tan-gray; thin-bedded; some limonite stains on bedding planes. Crinoid columnals, echinoid spines, and Derbyia sp. 2.3
Limestone, hard, argillaceous; tan-gray, weathers tan; massive, weathers blocky. 3
Shale, clayey, some silt, calcareous; tan-brown weathers tan; thin-bedded; some limonite stains. 1.4
Shale, clayey, calcareous; green, weathers light green; thin-bedded to blocky. 1.2
Shale, silty, calcareous; maroon mottled with green; blocky to thin-bedded to blocky; iron stains on fracture planes. 1.3
Shale, clayey, calcareous; light green; blocky; some iron stains. 7
Shale, silty, calcareous; maroon mottled with green in upper part; thin-bedded to blocky. 2.7
Shale, silty, noncalcareous; green mottled with purple and grading downward to purple at base; blocky; limonite-stained. 2.4
Shale, clayey with some silt, calcareous; green mottled with purple and maroon at base; thin-bedded; iron-stained. 6
Shale, silty, calcareous; maroon; blocky. 7

Funston limestone. (6.8 feet)
Limestone, hard; light gray weathers tan-gray; massive, weathers blocky. 1.2
Shale, clayey, some silt, calcareous; gray with purple in middle; thin-bedded; some limonite stains. . . . 3.5
Limestone, soft; gray-orange, weathers tan-gray; massive; porous, sandy appearance, rotten, a band of chert nodules present in upper part. 2.1

Blue Rapids shale. (17.6 exposed)
Shale, silty, very calcareous; tan-gray mottled with maroon, weathers light gray; thin-bedded; calcium carbonate stains abundant, calcareous nodules and limonite stains common, thin, platy limestone bed zone is near the base. 3.7

Shale, clayey, calcareous; gray-green; thin-bedded; limonite-stained. 1.4
Shale, clayey, noncalcareous; gray-green, weathers light gray-green; thin-bedded to blocky; limonite-stained. 3.2
Shale, clayey, noncalcareous; maroon mottled with purple and some light gray; thin-bedded to blocky. 1.1
Shale, silty with some clay, calcareous; light gray-green mottled with purple in upper part, weathers light gray; thin-bedded; iron stains abundant. 2.8
Shale, silty, calcareous; purple with maroon tint, weathers purple; thin-bedded; some limonite stains. . . . 0.8
Shale, silty, calcareous; gray-green weathers light gray-green; thin-bedded. 7
Shale, silty, slightly calcareous; purple; thin-bedded; numerous small calcareous nodules at base. 2.4
Shale, silty, calcareous; green becoming gray-green at base; thin-bedded; numerous calcareous nodules, limonite-stained. 1.5

Covered interval, colluvium, thin limestone plates on surface 11.7

Crouse limestone. (1.9 feet exposed)
Limestone, hard; tan-gray; massive, weathers blocky; porous. 1.9

Easly Creek shale. (12 feet exposed)
Shale, silty, calcareous; gray-green, weathers tan-gray; thin-bedded; limonite-stained. 4.7
Limestone, hard, dense; gray to tan-gray, weathers tan-gray; massive; numerous small limonite and clay balls in lower part, give conglomeratic appearance. Numerous fossil fragments and some microfossils. . 1.8
Shale, clayey with some silt, calcareous; gray-green grading downward to maroon at base; thin-bedded; numerous calcium carbonate nodules in upper top part. 5.5

Base covered.

Section 32

This section from the Fort Riley limestone member of the Barneston limestone to the Blue Springs member of the Matfield shale, inclusive, is exhibited in a road cut in the NW¼ NE¼ sec. 17, T. 6 S., R. 6 E.

	Feet
Soil, silty; gray-brown.	1 ±
Barneston limestone. (32.9 feet exposed)	
Fort Riley limestone member. (5.3 feet exposed)	
Limestone, hard, dense; light gray, weathers tan-gray; massive, weathers blocky; porous. Derbyia sp., Meekella striatocostata, echinoid spines, crinoid columnals, and Composita sp. Forms hillside bench known locally as "rim rock".	5.3
Oketo shale member. (11.2 feet)	
Shale, silty, calcareous; tan-gray to gray, weathers tan-gray; thin-bedded to blocky; limestone lens in middle part; iron stains. Derbyia sp., Dictyoclostus americanus, Composita ovata, Derbyia crassa, crinoid columnals, echinoid spines, Meekella striatocostata, Polypora sp., Fenestella sp., Rhombopora sp., Amboccelia sp., and Aviculopecten occidentalis.	11.2
Florence limestone member. (22.4 feet)	
Limestone (partly exposed), hard, dense; tan to grey, weathers tan-gray; massive, weathers blocky; numerous chert lenses and nodules. Echinoid spines, crinoid columnals, and brachiopod fragments.	22.4
Matfield shale. (18.2 feet exposed)	
Blue Springs shale member. (18.2 feet exposed)	
Shale, silty and clayey, mostly calcareous; gray-green and tan-gray in upper part; maroon in the lower part; thin-bedded to blocky; thin limestone lens in upper part; some limonite stains.	18.2

Base covered.

Section 33

This section of the Barneston limestone is exposed in a road cut in the SE¼ SW¼ sec. 10, T. 8 S., R. 6 E.

	Feet
Soil, gray-brown, silty.	2 ±
Barneston limestone. (27.9 feet exposed)	
Fort Riley limestone member. (7.5 feet exposed)	
Limestone, hard, dense; tan-gray, weathers light gray; massive, weathers in large blocks; porous. Echinoid spines.	4.1
Shale, silty, calcareous; tan; thin-bedded; numerous calcareous plates. Echinoid spines, crinoid columnals, Derbyia crassa, Dictyoclostus sp., and Ambocoelia expansa.	2.2
Limestone, hard; gray-orange, weathers tan; massive, weathers platy; some limonite stains. Rhombopora sp., crinoid columnals, and echinoid spines.	1.2
Oketo shale member. (9.2 feet)	
Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded; calcareous lenses. Dictyoclostus americanus, Composita ovata, Rhombopora sp., Fenestella sp., crinoid columnals, Aviculopecten occidentalis, Pelecrophon sp., Polypora sp., Derbyia crassa, D. cymbula, D. nebrascensis, Echinoconchus sp., Myalina sp., Meekella striatocostata, Ambocoelia sp., and Rustedia mormoni.	5.3
Limestone, hard; tan-gray, weathers tan; massive, weathers in blocks and irregular fragments. Crinoid columnals, echinoid spines, Rhombopora sp., Derbyia sp., and Dictyoclostus sp.	1.3
Shale, silty, calcareous; gray-brown, weathers tan; thin-bedded; some calcareous lenses; limonite stains.	2.6
Florence limestone member. (11.2 feet exposed)	
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; chert lenses and nodules. Echinoid spines, Rhombopora sp., Ambocoelia sp., crinoid columnals and few brachiopod fragments.	11.2

Base covered.

Section 34

This section of the Barneston limestone is exposed in a road cut in the NE¼ SW¼ sec. 15, T. 7 S., R. 6 E.

	Feet
Soil, silty; black.	2 ±
Barneston limestone. (40.4 feet exposed)	
Fort Riley limestone member. (6.4 feet exposed)	
Limestone, hard; gray-brown, weathers tan-gray; massive, weathers blocky; porous; limonite-stained. Crinoid columnals.	1.1
Limestone, hard, dense; tan-gray; massive, weathers in large blocks; porous; few iron stains. *Derbyia crassa*, crinoid columnals, and brachiopod fragments. Forms hillside bench known locally as "rim rock". .	5.3
Oketo shale member. (8.7 feet)	
Shale, silty, calcareous; gray to tan-gray, weathers tan-gray; thin-bedded; numerous calcareous lenses. *Dictyoclostus americanus*, *D. portlockianus*, *Polypora* sp., *Rhombopora* sp., *Derbyia crassa*, *D. cymbula*, *D. hooseriensis*, *Ambocoelia expansa*, *Composita ovata*, *Fenestella* sp., and *Hyalina copei*.	8.7
Florence limestone member. (25.3 feet exposed)	
Limestone, hard, crystalline in part; gray, weathers tan-gray; massive, weathers blocky and shaly at top. Some chert nodules. Echinoid spines, crinoid columnals and *Derbyia* sp.	2.3
Shale, silty, calcareous; tan-gray; thin-bedded; some iron stains. *Derbyia crassa*, *Rhombopora* sp., *Fenestella*, crinoid columnals, *Polypora* sp., *Aviculopecten occidentalis*, and echinoid spines.	3.3
Limestone, hard; tan-gray; massive, weathers blocky; chert nodules; some limonite stains. *Derbyia crassa*, *Dictyoclostus americanus*, echinoid spines, and brachiopod fragments.	3.6
Shale, silty, calcareous; olive drab, weathers tan-gray; thin-bedded, *Derbyia crassa*, crinoid columnals, and echinoid spines.	.4
Limestone, hard; gray, weathers tan-gray; massive, weathers shaly and blocky; chert nodules.	1.4
Limestone, hard, dense; tan-gray to gray; weathers tan-gray; massive, weathers blocky and nodular; numerous chert lenses and nodules; some iron stains.	14.3
Base covered.	

Section 35

This section of the Barneston limestone is exposed in a road cut in the SE¼ NW¼ sec. 32, T. 6 S., R. 5 E.

Feet

Top eroded

Barneston limestone. (38.0 feet exposed)
Fort Riley limestone member. (5.3 feet present)
Limestone, hard; tan, weathers tan-gray; massive, weathers blocky at top and platy at base; porous. Echinoid spines, crinoid columnals, Derbyia sp., and brachiopod fragments. Forms hillside bench known locally as "rim rock". 3.3
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; numerous calcareous lenses. Echinoid spines, and crinoid columnals. 0.9
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky. Crinoid columnals, echinoid spines, Rhombopora sp., Fenestella sp., Meekella striatocostata, and brachiopod fragments. 1.2

Oketo shale member. (9.1 feet)
Shale, silty, calcareous; tan; thin-bedded; some iron stains. Polypora sp., Derbyia crassa, crinoid columnals, Rhombopora sp., Composita ovata, Fenestella sp., and Dictyoclostus americanus. 9.1

Florence limestone member. (23.6 feet exposed)
Limestone, hard, dense; tan-gray; massive, weathers blocky; chert nodules. Composita sp., echinoid spines, crinoid columnals, Amboccelia sp. 1.0
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous lenses. Dictyoclostus americanus, D. portlockianus, Rhombopora sp., Fenestella sp., and Fistulipora sp. 2.0
Limestone, hard, dense; tan-gray; massive, weathers blocky; numerous chert nodules; iron-stained. Dictyoclostus portlockianus, Derbyia crassa, echinoid spines, crinoid columnals, and Amboccelia sp. . . . 3.4
Shale, silty, very calcareous; tan-gray, weathers tan; thin-bedded; numerous calcareous lenses. Dictyoclostus portlockianus, Meekella striatocostata, Wralina copei, Derbyia sp., Polypora sp., Rhombopora sp., Astartella sp., Derbyia crassa, echinoid spines, crinoid columnals, Stenopora sp., and Fenestella sp. 1.4
Limestone, hard, dense; light gray, weathers tan-grey; massive, weathers blocky; numerous chert nodules and lenses; some iron stains. Echinoid spines and crinoid columnals. 2.8

Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; numerous calcareous nodules and lenses. 0.9

Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky to nodular; numerous chert lenses and nodules. Echinoid spines, crinoid columnals, Rhombopora sp., Fenestella sp., Amboccelia sp., and Derbyia sp. 11.2

Base covered.

Section 36

This section from the Towanda limestone member of the Doyle shale to the Florence limestone member of the Barneston limestone, inclusive, is exhibited in a road cut in the NE¼ NW¼ sec. 6, T. 7 S., R. 6 E.

	Feet
Soil, silty; gray; limestone and chert fragments.	1 ±
Doyle shale. (28.4 feet exposed)	
Towanda limestone member. (7.6 feet exposed)	
Limestone, hard, dense; gray-brown, weathers tan-gray; massive, weathers blocky to platy; porous and cavernous in part; iron stains; small structure.	7.6
Holmesville shale member. (18.8 feet)	
Shale, silty calcareous; tan-gray to gray-green; thin-bedded to blocky; heavily limonite-stained zone near the base.	11.2
Limestone, argillaceous, hard; tan-gray; massive, weathers blocky; penecontemporaneous folding. . . .	0.5
Shale, silty, very calcareous; gray-brown, weathers tan; blocky to thin-bedded; limonite stains, calcareous nodules.	1.6
Shale, silty, calcareous; gray-green; blocky.	5.5
Barneston limestone. (43.5 feet exposed)	
Fort Riley limestone member. (38.2 feet)	
Limestone, soft; tan-gray to gray, weathers tan; massive, weathers shaly in lower part and blocky in upper part; porous; numerous limonite stains. . . .	25.1
Limestone, soft, dolomitic; gray-orange, weathers tan-gray; massive, weathers blocky; limonite-stained, porous. Forms hillside bench locally called "rim rock".	7.1
Oketo shale member. (8.9 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous lenses and plates. Composita sp., Dictyoclostus americanus, Polypora sp., Derbyia crassa, Ambocoelia sp., crinoid columnals, echinoid spines, Rhombopora sp., and Penestella sp.	8.9
Florence limestone member. (2.4 feet exposed)	
Limestone, hard; tan-gray, weathers tan; massive weathers shaly and blocky; some chert nodules. Echinoid spines, crinoid columnals, Rhombopora sp., Composita sp.	2.4
Base covered.	

Section 37

This section of the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a stream bank and quarry in the NW¼ NE¼ sec. 11, T. 9 S., R. 4 E.

	Feet
Soil, silty and clayey; dark gray; some limestone gravel. .	1 ±
Doyle shale. (41.2 feet interval)	
Towanda limestone member. (13.7 feet exposed)	
Limestone, hard, dense in part; gray-orange to gray, weathers gray-orange; massive, weathers blocky and platy; limonite stains abundant; porous in part. . . .	13.7
Holmesville shale member. (20.5 feet interval)	
Shale (middle and basal parts covered), silty, calcareous; tan; thin-bedded.	20.5
Barneston limestone. (3.3 feet exposed)	
Fort Riley limestone member. (3.3 feet exposed)	
Limestone, medium hard, dolomitic; gray; massive, weathers blocky; porous.	3.3
Base covered.	

Section 38

This section from the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a road cut in the SE¼ SW¼ SW¼ sec. 17, T. 7 S., R. 6 E.

	Feet
Soil; and weathered limestone.	1 +
Doyle shale. (28.5 feet exposed)	
Towanda limestone member. (3.6 feet exposed)	
Limestone, hard, dense; gray-orange to tan-gray, weathers tan-gray; massive, weathers blocky to platy; limonite-stained. Microfossils abundant in the basal part.	3.6
Holmesville shale member. (24.9 feet)	
Shale, silty, calcareous; gray-green to light gray at the top; thin-bedded to blocky; two calcareous lenses; heavily limonite-stained in upper part. . .	5.1
Shale, silty with some clay, slightly calcareous; maroon mottled with green and gray; thin-bedded to blocky; some iron stains on fracture planes.	5.2
Shale, silty, calcareous; gray-green, weathers tan-gray with maroon stains on the surface; thin-bedded.	3.9
Limestone, soft, dolomitic; tan-orange, weathers gray-brown; massive, weathers porous and rotten; limonite-stained. Pleurophorus sp., and microfossils. . . .	0.4
Shale, silty, calcareous; olive drab mottled with blue-gray; blocky; some iron stains.	1.8
Limestone, soft, argillaceous; olive drab, weathers tan-gray; massive, weathers blocky and shaly. . . .	.8
Shale, silty, calcareous; gray-green to tan-gray; blocky to thin-bedded; some limonite and carbon stains.	1.7
Limestone, medium hard, arenaceous; gray-brown; massive, weathers irregularly; heavily limonite-stained; penecontemporaneous folding.	.8
Shale, clayey, slightly calcareous; gray-green to tan-gray, weathers light gray-green; thin-bedded to blocky; some iron stains.	1.6
Shale, clayey, noncalcareous; gray; thin-bedded to blocky; some iron stains.	3.6
Barneston limestone. (26.8 feet exposed)	
Fort Riley limestone member. (26.8 feet exposed)	
Limestone, soft, dolomitic; tan-gray to dark gray; massive, weathers blocky; porous.	1.5
Shale, silty, calcareous; gray to blue-gray, weathers tan-gray; thin-bedded.	.2

Limestone, soft, dolomitic; gray to blue-gray; weathers tan-gray; massive, weathers blocky; porous; some limonite stains.	5.5
Limestone, hard, argillaceous; gray to blue-gray; massive, weathers platy; some iron stains.	7.4
Limestone, hard; gray-orange, weathers tan-gray; massive, weathers blocky; thin shale parting. . . .	3.7
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky; porous. Echinoid spines, crinoid columnals. Forms hillside bench locally called "rim rock".	3.2
Limestone, medium hard; gray to tan-gray, weathers tan-gray; massive, weathers blocky to shaly; shale partings; iron stains. Composita ovata, echinoid spines, Aviculopecten occidentalis, Stenopora sp., crinoid columnals, and Amboccelia sp.	6.3

Section 39

This section from the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a road cut in the SW¼ SE¼ sec. 31, T. 6 S., R. 5 E.

	Feet
Soil, silty; dark gray.	2 ±
Doyle shale, (21.2 feet exposed)	
Towanda limestone member. (3.8 feet exposed)	
Limestone, hard, dense in part; gray-orange, weathers tan-gray; massive, weathers blocky and platy; porous in middle part.	3.8
Holmesville shale member. (17.4 feet)	
Shale (partly covered), silty with some clay, calcareous; tan-gray to gray-green; thin-bedded to blocky.	11.2
Limestone, medium hard; tan-gray; massive, weathers blocky; porous. Loxonema sp., Pleurophorus sp., and microfossils.	0.7
Shale, silty, noncalcareous; tan-gray to gray-green; thin-bedded; some limonite stains on bedding planes.	5.5
Fort Riley limestone member. (30.3 feet exposed)	
Limestone, soft, dolomitic; tan-gray, weathers tan; massive, weathers blocky; some iron stains.	.7
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; limonite stains on bedding planes.	2.4
Limestone, soft, fine-grained; gray-orange, weathers tan-gray; massive, weathers blocky; porous.	2.3
Limestone, medium hard, fine-grained, slightly dolomitic; gray to gray-orange, weathers tan-gray; massive, weathers blocky to platy to shaly; iron-stained. Pleurophorus sp., Hyalina sp., and few fossil fragments.	14.8
Limestone, hard; tan-orange, weathers tan-gray; massive, weathers blocky to shaly at the top; porous. Crinoid columnals and echinoid spines. Forms a hillside bench locally called "rim rock".	4.6
Limestone, hard; olive drab, weathers tan-gray; massive, weathers shaly; shale parting. Crinoid columnals and echinoid spines.	5.5
Base covered.	

Section 40

This section from the Towando limestone member of the Doyle shale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a road cut in the NE¼ SE¼ SE¼ sec. 29, T. 9 S., R. 6 E.

	Feet
Soil, silty, dark.	1 ±
Doyle shale. (12.3 feet exposed)	
Towanda limestone member. (12.3 feet exposed)	
Limestone, hard, dense, somewhat crystalline in places; gray-orange, weathers light gray; massive, weathers blocky to platy in the upper part; thin shale parting near middle; limonite stains and nodules abundant; porous. Badly fractured, some folding. Some echinoid spines in basal part.	12.3
Holmesville shale member. (19.1 feet)	
Shale, silty, calcareous; maroon at base grading up into gray, weathers maroon to tan; thin-bedded; calcareous nodules and lenses common, heavily limonite-stained in upper part.	7.2
Limestone, argillaceous, soft; gray-green, weathers light gray; nodular; cavernous.	0.6
Shale, clayey, calcareous; gray-green grading into maroon; thin-bedded; calcareous nodules at the base.	1.8
Limestone, hard, argillaceous; gray with a green tint, weathers light gray; blocky; nodular; limonite stains abundant.	2.1
Shale, silty becoming clayey in the upper part, very calcareous; gray grading up into mottled maroon and gray; blocky to thin-bedded; calcareous nodules abundant, iron-stained.	1.9
Covered interval.	5.5
Barneston limestone. (27.8 feet exposed)	
Fort Riley limestone member. (27.8 feet exposed)	
Limestone, soft, dense, somewhat argillaceous, slightly dolomitic; tan-gray, weathers tan; massive, weathers thin-bedded to shaly; numerous shale partings; porous; weathers cavernous in upper part. *Pleurophorus albequus* abundant, *Aviculopecten occidentalis*, and *Yoldia* sp., fossils are in basal part only.	14.5
Shale, clayey, noncalcareous; dark gray, weathers gray; thin-bedded.	.2
Limestone, soft, argillaceous; tan-gray; massive, weathers platy.	1.6

Limestone, hard, argillaceous, dense; tan to blue-gray; massive, weathers blocky and platy. 7.3

Limestone, hard, dense; gray-orange, weathers gray; massive weathers to large blocks; porous. Echinoid spines, crinoid columnals, and Derbyia crassa. Forms a prominent hillside bench, known locally as the "rim rock". 4.2

Base covered.

Section 41

This section from the Towanda limestone member of the Doyle shale to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a road cut in the SW¼ SE¼ sec. 24, T. 8 S., R. 6 E

	Feet
Soil, silt and clay; brown to gray.	15 ±
Doyle shale. (13.6 feet exposed)	
Towanda limestone member. (13.6 feet exposed)	
Limestone, hard, dense, argillaceous in part; gray-orange, weathers tan; massive, weathers platy to blocky; numerous iron stains, slightly porous. Some microfossils in the lower part.	13.6
Holmesville shale member. (19.1 feet)	
Shale, silty, calcareous, slightly arenaceous in the upper part; green to tan-gray, becoming green, gray and maroon at the base; thin-bedded to blocky; limonite stains abundant, calcareous zone near the middle.	16.1
Limestone, hard, dense in part; tan-gray to tan; massive, weathers irregular and blocky; porous at the base. Some microfossils present.	1.5
Shale, silty, calcareous; tan-gray; thin-bedded, becoming blocky and massive at base.	1.5
Barneston limestone. (30.2 feet exposed)	
Fort Riley limestone member. (30.2 feet exposed)	
Limestone, soft; tan-gray to tan; massive, weathers irregular, blocky, shaly, and in thin plates; on the weathered surface this limestone looks like a shale; porous, numerous limonite stains.	10.7
Limestone, soft; gray-orange, weathers tan-gray; massive, weathers in small blocks; limonite-stained. The following fossils occur abundantly: Aviculopecten occidentalis, Pleurophorus albequus, and other pelecypods.	2.2
Limestone (mostly covered).	7.1
Limestone, soft; gray-orange to gray, weathers tan-gray; massive, weathers blocky to platy on top; numerous limonite stains; porous. Pleurophorus albequus abundant, Pleurophorus sp., and Aviculopecten occidentalis.	10.2

Base covered.

Section 42

This section from the Cresswell limestone member of the Winfield limestone to the Fort Riley limestone member of the Barneston limestone, inclusive, is exposed in a road cut in the NE¼ SE¼ sec. 14, T. 6 S., R. 6 E.

	Feet
Soil, silty, gray; weathered shale.	3 -
Winfield limestone. (10.0 feet)	
Cresswell limestone member. (1.4 feet exposed)	
Limestone, hard; gray-brown, weathers tan-gray; massive, weathers blocky; iron-stained. Echinoid spines abundant, crinoid columnals, *Derbyia* sp., and *Rhombopora* sp.	1.4
Grant shale member. (7.7 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; limonite-stained. Crinoid columnals, *Derbyia crassa*, *Rhombopora* sp., echinoid spines, *Chonetes granulifera*, and *Dictyoclostus americanus*.	7.7
Stovall limestone member. (0.9 feet)	
Limestone, hard; tan, weathers tan-gray; massive, weathers blocky; numerous chert nodules; some limonite stains. *Dictyoclostus americanus*, *Derbyia crassa*, and echinoid spines.	0.9
Doyle shale. (63.7 feet)	
Gage shale member. (36.6 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; numerous limonite stains. *Derbyia crassa*, *D. cimbula* and *D. kooskiensis*.	6.8
Limestone, soft, arenaceous; tan to tan-gray, weathers tan; massive, weathers blocky; limonite-stained.	.6
Shale, silty, calcareous; maroon to gray-green, gray in upper part; thin-bedded to blocky; thin calcareous zone in upper part.	7.8
Covered interval.	21.2
Towanda limestone member. (12.8 feet)	
Limestone, hard, dense in part; tan-brown, weathers tan to tan-gray; massive, weathers platy to blocky.	12.8
Holmesville shale member. (14.3 feet)	
Shale (partly covered), silty, calcareous; tan with some maroon and green in upper part becoming gray and tan at basal part; thin-bedded to blocky. . . .	14.3

Barneston limestone. (20.3 feet exposed)
Fort Riley limestone member. (20.3 feet exposed)

Limestone, soft; tan-gray, weathers tan; massive, weathers shaly to thin-bedded; some limonite stains.	8.7
Shale, silty, very calcareous; tan; thin-bedded; numerous calcareous lenses.	5.5
Limestone, soft; tan-gray, weathers tan; massive, weathers blocky; some limonite stains in pore spaces.	6.1

Base covered.

Section 43

This section from the Cresswell limestone member of the Winfield limestone to the Towanda limestone member of the Doyle shale, inclusive, is exposed in an old road cut in the NE¼ SE¼ sec. 19, T. 7 S., R. 5 E.

	Feet
Soil, dark gray, silty, with weathered limestone fragments.	2 +
Winfield limestone. (20.3 feet exposed)	
Cresswell limestone member. (10.5 feet exposed)	
Limestone, soft; tan to gray-orange, weathers tan-gray; massive, weathers in thin plates at the base and cavernous in the top part; numerous geodes. . .	8.3
Limestone, soft, dolomitic; tan-gray to gray-orange, weathers tan-gray; massive, weathers blocky.	2.4
Grant shale member. (9.1 feet)	
Shale, silty, calcareous; tan-gray to gray, weathers tan; thin-bedded; limonite-stained on bedding planes, numerous calcareous plates.	9.1
Stovall limestone member. (0.5 feet)	
Limestone, medium hard; tan-gray; massive, weathers platy and nodular; chert nodules. *Myalina* sp., and *Polypora* sp.	0.5
Doyle shale. (42.2 feet exposed)	
Gage shale member. (40.2 feet)	
Shale, partly covered, mostly silty and noncalcareous; maroon with mottled gray-green in lower half, tan-gray and gray-green, thin-bedded to blocky; a thin limestone lens in the top half.	40.2
Towanda limestone member. (2.0 feet exposed)	
Limestone, hard, dense; gray-orange, weathers tan-gray; massive, weathers to form irregular blocks; limonite stains.	2.0

Base covered.

Section 44

This section from the Cresswell limestone member of the Winfield limestone to the Towanda limestone member of the Doyle shale, inclusive, is exhibited in a road cut in the NE¼ NE¼ secs. 24 and 25, T. 7 S., R. 5 E.

	Feet
Soil, silty, with some clay; gray.	1 ±
Winfield limestone. (16.6 feet exposed)	
Cresswell limestone member. (6.1 feet exposed)	
Limestone, soft, arenaceous in the lower part; tan-gray to light gray; massive, weathers blocky to platy; some iron stains. Fossil fragments in lower part. Small fault.	6.1
Grant shale member. (10.1 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded. Crinoid columnals, echinoid spines, Rhombopora sp., and few brachiopod fragments. . . .	10.1
Stovall limestone member. (0.4 feet)	
Limestone, hard, dense; light gray to dark gray; weathers tan-gray; massive, weathers blocky to nodular; numerous chert nodules; some iron stains. Rhombopora sp., and a few fossil fragments.	0.4
Doyle shale. (47.4 feet exposed)	
Gage shale member. (37.6 feet)	
Shale, silty, with some clay, calcareous; tan-gray becoming gray-green in basal part.	8.7
Shale, clayey, with some silt, silty in upper part, noncalcareous; maroon, mottled with green and contains green lens; blocky to thin-bedded; some iron stains on fracture planes.	28.9
Towanda limestone member. (9.8 feet exposed)	
Limestone, hard, becoming soft and dolomitic at the top; gray-orange to tan-gray; massive, weathers blocky to platy.	9.8
Base covered.	

Section 45

This section from the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exposed in a railroad cut in the NW¼ NE¼ NE¼ sec. 1, T. 9 S., R. 4 E.

	Feet
Soil, silty, dark; weathered limestone fragments.	3 ±
Winfield limestone. (19.3 feet exposed)	
Cresswell limestone member. (8.9 feet exposed)	
Limestone, soft, slightly dolomitic; light gray to cream, weathers tan; massive, weathers blocky to shaly.	2.6
Limestone, hard, fine-grained; light gray, weathers tan-gray; massive, weathers blocky to platy in upper part. Echinoid spines and crinoid columnals. . . .	6.3
Grant shale member. (9.1 feet)	
Shale, silty with some clay, calcareous; tan-gray, weathers tan; thin-bedded; calcareous zone near the top; limonite-stained. *Derbyia crassa*, *D. cymbula*, *Dictyoclostus americanus*, *D. portlockianus*, *Composita ovata*, *C. subtilita*, crinoid columnals, *Astartella* sp., *Polypora* sp., *Rhombopora* sp., *Hyalina* sp., *Hyalina copei*, and *Aviculopecten occidentalis*. .	9.1
Stovall limestone member. (1.3 feet)	
Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocky; numerous chert nodules; limonite-stained. *Stenopora* sp., *Dictyoclostus americanus*, and *Derbyia crassa*.	1.3
Doyle shale. (1.7 feet exposed)	
Gage shale member. (1.7 feet exposed)	
Shale, silty, very calcareous; tan-gray, weathers tan; thin-bedded to platy.	1.7

Section 46

This section from the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exhibited in a road cut in the SE¼ SW¼ sec. 18, T. 7 S., R. 5 E.

	Feet
Weathered limestone and dark silty soil.	1 ±
Winfield limestone. (15.05 feet)	
Cresswell limestone member. (6.6 feet exposed)	
Limestone, hard, dolomitic; tan-gray; massive, weathers blocky to shaly in upper part; limonite stains and shale parting near base.	6.6
Grant shale member. (8.2 feet)	
Shale, silty, noncalcareous; tan-gray to olive drab, weathers tan; thin-bedded; calcareous lens in the middle, some limonite stains. Fossils rare or absent.	8.2
Stovall limestone member. (0.25 feet)	
Chert nodules in a limestone matrix, limonite-stained.	0.25
Doyle shale. (1.8 feet exposed)	
Gage shale member. (1.8 feet exposed)	
Shale, silty, slightly calcareous; olive drab; blocky; iron stains on fracture planes.	1.8
Base covered.	

Section 47

This section of the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exposed in a road cut in the SW¼ SW¼ sec. 34, T. 7 S., R. 6 E.

	Feet
Soil, silty, dark gray-brown.	1 ±
Winfield limestone. (11.0 feet exposed)	
Cresswell limestone member. (1.5 feet exposed)	
Limestone, hard; tan, weathers tan-gray; massive, weathers thin-bedded to blocky. Echinoid spines and crinoid columnals.	1.5
Grant shale member. (8.7 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; limonite stains. Crinoid columnals, echinoid spines, Derbyia crassa, Rhombopora sp., Polypora sp., Composita sp., and Dictyoclostus americanus.	8.7
Stovall limestone member. (0.8 feet)	
Limestone, hard, dense; grey, weathers gray to light gray; massive, weathers blocky; numerous chert nodules; few iron stains. Echinoid spines and crinoid columnals.	0.8
Doyle shale. (7.3 feet exposed)	
Gage shale member. (7.3 feet exposed)	
Shale, clayey with some silt, calcareous; tan-gray, weathers tan; thin-bedded; limonite-stained. Derbyia crassa and D. cymbula.	7.3
Base covered.	

Section 43

This section from the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exhibited in a road cut in the W½ NW¼ sec. 31, T. 9 S., R. 5 E.

	Feet
Weathered limestone.	3 -
Winfield limestone. (21.6 feet exposed)	
Cresswell limestone member. (7.25 feet exposed)	
Limestone, soft; tan, weathers tan-gray; massive, weathers platy and cavernous; becomes shaly in middle part.	3.1
Shale, silty, calcareous; tan; thin-bedded.	0.1
Limestone, hard, dense; gray, weathers tan-gray; massive, weathers blocky; maroon stains on fracture planes. Echinoid spines.	.9
Shale, clayey with some silt, calcareous; gray, weathers tan; thin-bedded.	.05
Limestone, hard, dense; tan to gray, weathers tan; massive, weathers blocky; maroon stains on fracture planes. Echinoid spines, crinoid columnals, and some brachiopod fragments.	3.1
Grant shale member. (11.5 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded. Composita ovata, Derbyia crassa, crinoid columnals, Polypora sp., Rhombopora sp., Dictyoclostus americanus, and organic burrows? . . .	11.5
Stovall limestone member. (2.8 feet)	
Limestone, hard, dense; tan-gray, weathers tan; massive, weathers blocky; numerous chert nodules. Polypora sp., Dictyoclostus americanus, D. portlocklanus, echinoid spines, crinoid columnals. Extremely folded and faulted.	2.8
Doyle shale. (10.3 feet exposed)	
Gage shale member. (10.3 feet exposed)	
Shale, silty, calcareous; tan to gray, weathers tan; thin-bedded; some limonite stains on bedding planes. Derbyia cimbula, D. crassa, D. kooseensis, crinoid columnals, Stenopora sp., Polypora sp., Rhombopora sp., Aviculopecten occidentalis, and echinoid spines.	10.3

Base covered.

Section 49

This section from the Cresswell limestone member of the Winfield limestone to the Gage shale member of the Doyle shale, inclusive, is exposed in a road cut in the NW¼ NW¼ sec. 33, T. 8 S., R. 6 E.

	Feet
Soil and weathered limestone.	1 ±
Winfield limestone. (24.8 feet exposed)	
Cresswell limestone member. (14.4 feet exposed)	
Limestone (partly covered) hard, dense; gray to tan-gray, weathers tan-gray; massive, weathers blocky to platy; porous, cavernous; some iron stains. Forms second Cresswell hillside bench.	12.2
Limestone, hard; tan-gray; massive, weathers blocky to shaly at base. Echinoid spines, crinoid columnals and brachiopod fragments. Forms a hillside bench. .	2.2
Grant shale member. (9.1 feet)	
Shale, silty, calcareous; gray to tan-gray; thin-bedded to blocky; iron stains. *Derbyia crassa*, *Dictyoclostus americanus*, *Composita ovata*, crinoid columnals, *Rhombopora* sp., *Allorisma* sp., and *Polypora* sp.	9.1
Stovall limestone member. (1.3 feet)	
Limestone, hard, dense; gray to tan-gray, weathers tan-gray; massive, weathers blocky; numerous chert nodules which are heavily iron-stained. Crinoid columnals. Fault, with about 4 feet displacement, is present and reflects into Cresswell limestone. .	1.3
Doyle shale. (21.2 feet exposed)	
Gage shale member. (21.2 feet exposed)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded; calcareous lens in middle; iron stains. *Dictyoclostus americanus*, *Derbyia crassa*, *D. cymbula*, *D. hooseriensis*, crinoid columnals, echinoid spines, and *Aviculopecten occidentalis*. . .	5.4
Limestone, hard, argillaceous; tan-gray, weathers tan; massive, weathers blocky; iron stains. *Derbyia crassa*, crinoid columnals, echinoid spines, and *Dictyoclostus americanus*.	0.4
Shale, silty, silty with clay, calcareous; gray-green, weathers tan; thin-bedded. *Derbyia crassa* and crinoid columnals.	2.3
Limestone, hard, argillaceous; gray, weathers tan; massive, weathers blocky to shaly. Some microfossils.	.4

Shale, silty, calcareous; gray-green to tan, weathers tan-gray; thin-bedded; limonite stains on bedding planes; calcite-filled fractures.	6.1
Shale, silty, calcareous; maroon mottled with green and contains green lenses; thin-bedded to blocky. .	6.6

Base covered.

Section 50

This section of the Winfield limestone is exposed in a road cut in NW¼ SW¼ sec. 36, T. 6 S., R. 4 E.

	Feet
Limestone weathered.	4 ±
Winfield limestone. (10.1 feet exposed)	
Cresswell limestone member. (1.7 feet exposed)	
Limestone, hard; tan-gray, weathers tan; massive, weathers blocky. Echinoid spines, crinoid columnals, and brachiopod fragments.	1.7
Grant shale member. (7.7 feet exposed)	
Shale, silty, calcareous; olive drab to tan-gray, weathers tan; thin-bedded to blocky; iron-stained. Crinoid columnals, *Derbyia crassa*, echinoid spines, *Aviculopecten occidentalis*, *Dictyoclostus americanus*, *Composita ovata*, and *Ambocoelia* sp.	7.7
Stovall limestone member. (0.7 feet)	
Limestone, hard, dense; light gray to dark gray, weathers tan-gray; massive, weathers blocky; numerous chert nodules. Echinoid spines, *Dictyoclostus americanus*, crinoid columnals, *Derbyia cymbula*, and *D. portlockianus*.	0.7
Base covered.	

Section 51

This section of part of the Winfield limestone, including the Cresswell limestone member and the Grant shale member, was measured in a road cut in the NW¼ NW¼ sec. 30, T. 9 S., R. 5 E.

	Feet
Soil, silty; gray-brown.	1 ±
Winfield limestone. (15.3 feet exposed)	
Cresswell limestone member. (11.2 feet exposed)	
Limestone, soft becoming hard in basal part, fine-grained; tan-gray, weathers tan; massive, weathers blocky to platy; shale zone near base; calcium carbonate-lined caverns, iron stains on fracture planes.	7.5
Limestone, hard, dense; tan, weathers tan-gray; massive; slightly porous. Echinoid spines, Composita sp., crinoid columnals, and brachiopod fragments. .	3.7
Grant shale member. (4.1 feet exposed)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; some limonite stains. Crinoid columnals, Allorisma terminale, Derbyia cymbula, and D. crassa.	4.1

Base covered.

Section 62

This section from the Herington limestone member of the Nolans limestone to the Cresswell limestone member of the Winfield limestone, inclusive, is exhibited in a road cut in the SE¼ SW¼ sec. 36, T. 6 S., R. 4 E.

	Feet
Soil, silty; dark gray; limestone fragments.	2 -
Nolans limestone. (14.4 feet exposed)	
Herington limestone member. (1.5 feet exposed)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded to blocky; iron-stained.	1.2
Limestone, soft, argillaceous; gray, weathers tan-gray; massive, weathers blocky; iron-stained. Derbyia cymbula, D. looseriensis, Aviculopecten occidentalis, and Hyalina sp.	0.3
Paddock shale member. (12.0 feet)	
Shale, silty, slightly calcareous; tan-gray to gray weathers tan; thin-bedded to blocky; iron-stained. Molds and casts of Aviculopecten occidentalis. . . .	12.0
Krider limestone member. (0.9 feet)	
Limestone, soft, dolomitic; tan-gray, weathers tan; massive, weathers blocky; shale parting. Aviculopecten occidentalis and few small pelecypods. . . .	.9
Odell shale. (22.7 feet)	
Shale, silty, slightly calcareous; gray-green to tan-gray mottled with maroon in basal part; thin-bedded to blocky; iron-stained.	2.9
Shale, silty, noncalcareous; maroon with some gray and green mottled areas; blocky to thin-bedded. . .	12.4
Shale, clayey and silty, noncalcareous; gray-green mottled with maroon; thin-bedded; limonite-stained.	7.4
Winfield limestone. (11.2 feet exposed)	
Cresswell limestone member. (11.2 feet exposed)	
Limestone, hard; light gray, weathers tan-gray; massive, weathers blocky at base and platy to blocky in upper part. Echinoid spines in basal part. . . .	11.2

Base covered.

Section 53

This section from the Herington limestone member of the Nolans limestone to the Cresswell limestone member of the Winfield limestone, inclusive, is exposed in a road cut in the NW¼ SW¼ sec. 15, T. 6 S., R. 6 E.

	Feet
Soil and weathered limestone.	2 ±
Nolans limestone. (16.4 feet exposed)	
Herington limestone member. (0.6 feet exposed)	
Limestone, hard; gray-orange, weathers tan-gray; massive, weathers blocky; limonite stains. Small pelecypods very abundant.	0.6
Paddock shale member. (14.6 feet)	
Shale, silty, calcareous; tan-gray to gray, weathers tan-gray; thin-bedded to blocky; iron stains on bedding planes, cone-in-cone, calcareous planes near the base. Molds and casts of Aviculopecten occidentalis.	14.6
Krider limestone member. (1.2 feet)	
Limestone, soft, dolomitic; tan, weathers tan-gray; massive, weathers blocky; porous; numerous limonite stains.	1.2
Odell shale. (28.9 feet)	
Shale, silty, calcareous; tan-gray to gray-green, weathers tan-gray; limonite-stained.	3.7
Shale, silty, slightly calcareous; maroon mottled with green and green lenses; blocky to thin-bedded; some iron stains on fracture planes.	8.7
Covered interval.	16.5
Winfield limestone. (12.0 feet exposed)	
Cresswell limestone member. (12.0 feet exposed)	
Limestone, soft, dolomitic; light gray to gray-orange; weathers tan-gray to light gray; massive, weathers blocky; limonite-stained. Microfossils in upper part, Pleurophorus sp., and Yoldia sp., abundant. .	5.9
Shale, silty, calcareous; tan to gray; blocky to thin-bedded; numerous limonite stains.	6.1

Base covered.

Section 54

This section from the Herington limestone member of the Nolans limestone to the Odell shale, inclusive, is exposed in a road cut in the NW¼ NE¼ NE¼ sec. 8, T. 9 S., R. 5 E.

	Feet
Soil, silty; black.	2 ±
Nolans limestone. (13.4 feet exposed)	
Herington limestone member. (5.0 feet exposed)	
Limestone, hard; gray-orange; massive, weathers blocky; limonite-stained. Pelecypods abundant in certain zones.	0.4
Shale, silty, calcareous; tan; thin-bedded to blocky; calcareous nodules, iron-stained.	.9
Limestone, soft, argillaceous; tan-gray; massive, weathers blocky, some iron stains.	.7
Shale, silty with some clay, calcareous; tan; thin-bedded, some iron stains.	.2
Limestone, hard, slightly dolomitic, dense in part; tan-gray, weathers tan; massive, weathers blocky; two thin shale partings; limonite-stained; small geodes. *Pleurophorus* sp., and *Yoldia* sp.	2.8
Paddock shale member. (12.2 feet)	
Shale, clayey, noncalcareous; gray-brown, weathers tan; thin-bedded to blocky; few calcareous plates and iron stains. *Aviculopecten occidentalis*. . . .	12.2
Krider limestone member. (0.9 feet)	
Limestone, soft, dolomitic; gray-orange; massive weathers blocky and in chips; iron stains. *Pseudomontis hawni*, *Pleurophorus* sp., and *Aviculopecten occidentalis*.	.9
Odell shale. (1.5 feet exposed)	
Shale, silty, calcareous; tan-gray, weathers tan; blocky; some iron stains on fracture planes.	1.5

Base covered.

Section 55

This section from the Kerington limestone member of the Nolans limestone to the Odell shale, inclusive, is exposed in a road cut in the SE¼ SW¼ sec. 1, T. 8 S., R. 5 E.

	Feet
Soil, silty; black; rock fragments.	1 ±
Nolans limestone. (14.35 feet exposed)	
Kerington limestone member. (4.05 feet exposed)	
Limestone, medium hard, dolomitic; tan, weathers tan-gray; massive, weathers blocky. Pelecypod fragments very abundant. Pleurophorus sp., Aviculopecten occidentalis, and Myalina sp.	1.0
Shale, silty, calcareous; tan; thin-bedded.	0.25
Limestone, medium hard, dolomitic; light gray, weathers tan-gray; massive, weathers blocky; porous; limonite-stained. Pleurophorus sp., Myalina sp., Loxonema sp.	.9
Limestone, medium hard, fine-grained, dense in the upper part; tan-gray; massive, weathers blocky to thin chips limonite-stained. Numerous small Pleurophorus sp., Myalina sp., and Pseudomontis hawni.	1.9
Paddock shale member. (9.5 feet)	
Shale, silty, slightly calcareous; tan to gray, weathers tan-gray; thin-bedded to blocky; numerous limonite stains; thin calcareous lens near base. Aviculopecten occidentalis, Myalina sp., and Derbyia crassa.	9.5
Krider limestone member. (0.8 feet)	
Limestone, soft, sugary texture; tan-gray; massive, weathers to form irregular blocks; limonite-stained. Pleurophorus sp.	.8
Odell shale. (12.2 feet exposed)	
Shale, silty, noncalcareous; maroon at the base becoming gray-green in the upper part; thin-bedded to blocky; some limonite stains in the upper part. . .	12.2
Base covered.	

Section 56

This section from the Kerrington limestone member of the Nolams limestone to the Odell shale, inclusive, is exposed in a road cut in the [illegible] sec. 9, T. [illegible]., R. [illegible] E.

	Feet
Soil, silty, dark gray.	3 ±
Nolams limestone. (19.6 feet exposed)	
Kerrington limestone member. (6.5 feet exposed)	
Limestone, medium hard; tan, weathers tan-gray; massive, weathers blocky; porous; thin shale partings; numerous limonite specks.	5.5
Paddock shale member. (13.5 feet)	
Shale, clayey with some silt, noncalcareous; gray to tan, thin-bedded; thin calcareous zone near the base, limonite stains. Some fossil fragments.	13.5
Krider limestone member. (0.6 feet)	
Limestone, hard, dense; tan-gray; massive, weathers blocky; limonite stains common. Aviculopecten occidentalis, Pleurophorus sp., and other pelecypods.	0.6
Odell shale. (13.0 feet)	
Shale, silty, calcareous; tan-gray, weathers tan; thin-bedded in upper part, blocky in middle of lower parts.	.3
Shale, silty, calcareous; olive drab, weathers tan-gray; blocky to thin-bedded; iron stains common on the fracture planes.	2.5
Shale, silty, calcareous; gray-green, weathers light gray-green; blocky; iron-stained.	.6
Shale, silty, noncalcareous; gray to gray-brown with maroon stains at the base; blocky to thin-bedded; iron and carbon stains.	.9
Shale, silty, calcareous; maroon with green lenses and mottled areas; thin-bedded to blocky; slightly arenaceous; some carbon stains.	8.7

Base covered.

Section 37

This section from the Lerington limestone member of the Wolans limestone to the Odell shale, inclusive, is exhibited in a road cut in the NW¼ NE¼ sec. 14, T. [illegible], R. 4 E.

	Feet
Soil, silty; dark; weathered limestone fragments.	2 ±
Wolans limestone. (21.2 feet exposed)	
Lerington limestone member. (7.3 feet exposed)	
Limestone, medium hard, slightly dolomitic; tan-brown, weathers tan-gray; massive, weathers blocky with a thin shale parting. Pleuroplorus sp., Chaetetes sp., and Aviculopecten occidentalis.	5.3
Paddock shale member. (14.9 feet)	
Shale, silty with some clay, calcareous; tan-gray to gray, weathers tan; thin-bedded. Casts and molds of Aviculopecten occidentalis.	14.9
Krider limestone member. (1.0 feet)	
Limestone, soft, dolomitic; tan-gray, weathers tan; massive, weathers blocky; limonite specks. Pleuroplorus sp.	1.0
Odell shale. (6.1 feet exposed)	
Shale, silty, calcareous; tan and gray-green in upper part becoming maroon at base; thin-bedded.	6.1

Base covered.

Section 53

This section from the Herington limestone member of the Nolans limestone to the Odell shale, inclusive, is exposed in a road cut in the NE¼ SW¼ sec. 32, T. 7 S., R. 3 E.

	Feet
Limestone weathered.	1 ±
Nolans limestone. (10.0 feet exposed)	
Herington limestone member. (0.5 feet exposed)	
Limestone, medium hard, dense in part, dolomitic; gray-orange, weathers tan-gray; massive, weathers blocky; limonite-stained.	0.5
Paddock shale member. (14.7 feet)	
Shale, clayey with some silt, noncalcareous; gray to olive drab, weathers tan; thin-bedded to blocky; iron stains on bedding and fracture planes, calcareous zone in the lower part. Wellingia sp.	14.7
Krider limestone member. (0.8 feet)	
Limestone, medium hard, sugary texture; tan-gray; massive, weathers blocky; heavily limonite-stained in upper part; porous. Aviculopecten occidentalis and Pleuroplorus sp.	.8
Odell shale. (4.9 feet exposed)	
Shale, silty, calcareous; maroon at the base, gray-green in the upper part; blocky to thin-bedded. . .	4.9

Base covered.

Section 59

This section from the Wellington shale to the Herington limestone member of the Nolans limestone, inclusive, is exhibited in a stream bank in the N½ SW¼ sec. 1, T. 6 S., R. 4 E.

	Feet
Soil, silty, red-brown to gray.	2 ±
Wellington shale. (39.2 feet exposed)	
Limestone, hard, dense; tan-orange with purple bands, weathers tan-orange; massive, weathers porous and platy. Fossil fragments.	1.1
Shale, silty with some clay; calcareous; tan-gray, weathers light tan; thin-bedded; calcareous lenses, limonite-stained.	8.9
Shale, silty, calcareous; maroon with gray and gray-green lenses; thin-bedded to blocky; iron-stained. .	4.6
Shale, silty, calcareous; gray to light gray; thin-bedded to blocky; limonite stains, calcareous lenses.	3.4
Shale, silty with some clay; calcareous; maroon; thin-bedded to blocky.	0.9
Shale, clayey, noncalcareous; gray to tan-gray, weathers tan-gray; thin-bedded to blocky; heavily limonite-stained calcareous zone near the top.	2.2
Shale, clayey with some silt, calcareous; maroon; thin-bedded.	1.1
Shale, clayey with some silt, calcareous; light to dark gray-green mottled with maroon and purple; blocky; limonite stains on bedding planes.	4.3
Shale, silty, calcareous; maroon; thin-bedded; iron stains on fracture planes.	1.5
Shale (partly covered), silty, calcareous; tan-gray to gray, weathers tan; thin-bedded; limonite stains, carbon stains, and some calcareous plates.	11.2
Nolans limestone. (5.1 feet exposed)	
Herington limestone member. (5.1 feet)	
Limestone, soft, dolomitic; tan-brown; massive, weathers blocky; porous; limonite-stained.	5.1
Paddock shale.	

Section 60

This section of the Dakota formation to the Herington limestone member of the Nolans limestone, inclusive, is exposed in a road cut in the NW¼ NW¼ sec. 1, T. [illegible] S., R. 4 E.

	Feet
Soil, silty, arenaceous; gray-brown.	1 ±
Dakota formation. (4± feet)	
Sandstone and conglomeratic, fine to coarse sand mostly quartz, hard in part; dark brown; cross-bedded in part; massive weathers blocky; iron cemented, some ironstones, clay balls and limonite nodules.	4 ±
Wellington shale. (39.3 feet, interval)	
Limestone, hard; gray-orange; platy, porous.	0.6
Covered interval.	38.7
Nolans limestone. (4.1 feet exposed)	
Herington limestone member. (4.1 feet exposed)	
Limestone, medium hard, dolomitic; tan-brown, weathers tan; massive, weathers blocky and porous; iron-stained.	4.1

Base covered.